

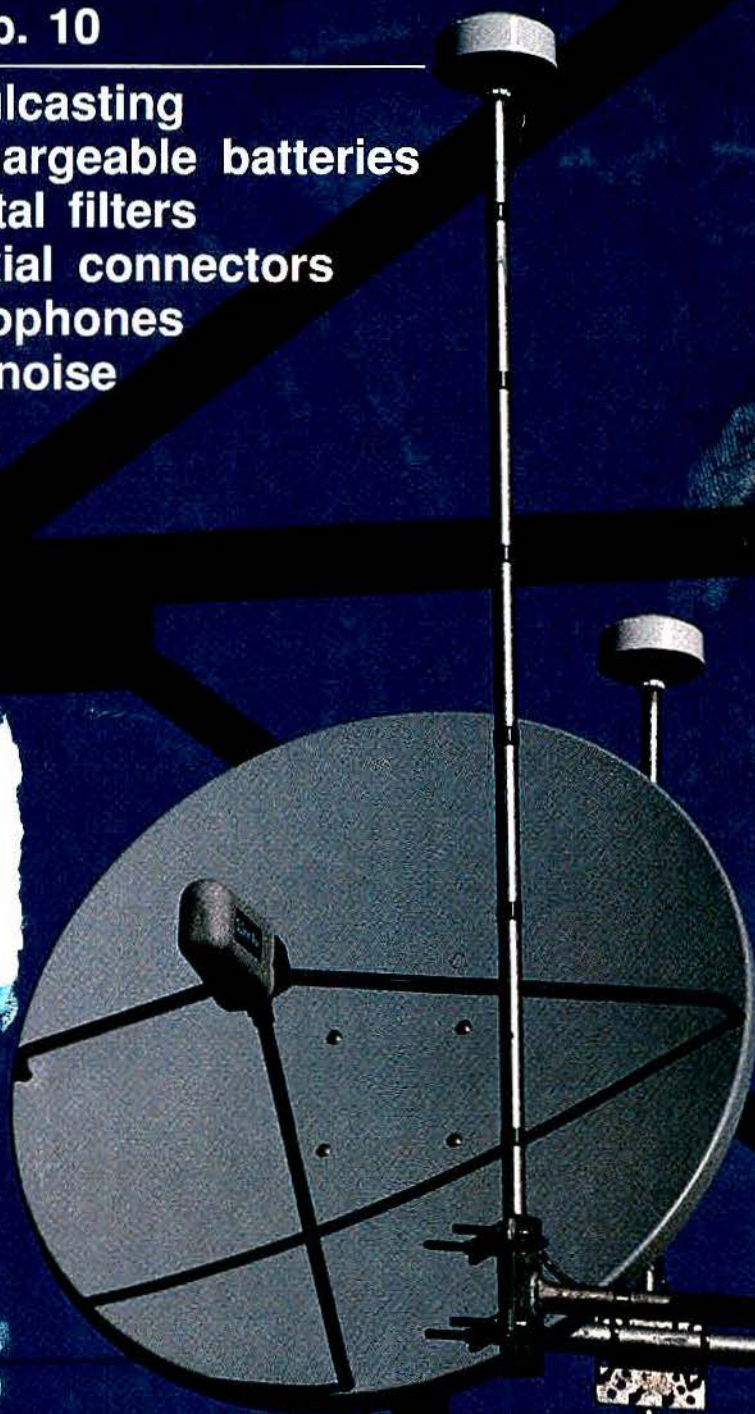
May 1995

# Mobile Radio Technology

The journal of mobile communications technology

**GPS, p. 10**

- Simulcasting
- Rechargeable batteries
- Crystal filters
- Coaxial connectors
- Microphones
- Site noise



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## features

- 10** GPS timing signals support simulcast synchronization

*Al Fisch*

- 16** Coverage proof of performance: Hocus-pocus or real world?

*Robert T. Forrest, P.E.*

- 34** Mesa, AZ, tests quasi-synchronous simulcasting

*Don Pfohl*

- 48** Improving the reliability of rechargeable batteries

*Isidor Buchmann*

- 54** Build a crystal filter to solve VHF interference

*Patrick E. Buller*

- 66** Coaxial connectors: 7/16 DIN and type N

*Jeffrey D. Paynter and Richard Smith*

- 74** Selecting and servicing two-way radio microphones

*Roald Steen*

- 77** Rechargeable alkaline batteries for portable two-way radios

*Donald E. Koehler*

## departments

- 4** Editorial

- 6** Calendar

- 8** Technically speaking  
Harold Kinley, C.E.T.  
Site noise and its effects.

- 86** Regulating technology  
Robert H. Schwaninger Jr.  
The voice of reason.

- 88** News  
Simmonds consolidates Midland, SCL Systems, Roamer One into public-company Intek Diversified.

- 93** New products  
Ace Communications is the "Readers' Choice."

- 103** Literature

- 104** People

- 106** Classified ads

- 128** Ad index/hot line  
Find advertisers quickly.



page 10



page 48

On the cover: GPS receivers, mounted on masts, help to synchronize simulcast signals for two Kansas City, MO, paging systems.

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## Scanning . . .



### Site frenzy

Where are network operators going to put all those new base stations for personal communications services (PCS)?

The best comparison with PCS is cellular telephone service, and cellular base stations number about 11,500. PCS, with its short-range signals, is expected to require about *five times as many sites*.

Despite the fact that many people want wireless communications, many of the same people do not want *evidence* of wireless communications in their neighborhoods, including satellite dishes, towers and base station antennas.

Faced with potential opposition from an estimated 38,000 local government commissions, network operators are seeking federal help to circumvent the power of these authorities. The FCC has been asked to preempt local regulation of these communications facilities.

The FCC previously has demonstrated reluctance to enact the kind of sweeping preemption of local regulation of communications facilities that network operators seem to want. About 10 years ago, responding to a request from radio amateurs to help them circumvent local regulation of antenna heights, the federal agency issued a limited preemption. All the FCC requires of local governments is a "reasonable accommodation" for amateur antennas. "Reasonable accommodation" is subject to wide interpretation by local authorities and courts. Thus, amateur station operators still have to lobby local governments just about as hard as ever and sometimes have to pursue court challenges. We doubt that this type of preemption is what commercial wireless network operators have in mind.

What they want is freedom from almost

all local regulation so they can place base station facilities just about anywhere a private property owner will let them. Let's face it: nascent PCS network operators have ponied up more than \$7 billion for licenses. (Amateur radio licenses are free.) Despite the amount of money involved, can the FCC now turn its back on real estate industry and local government lobbyists in their opposition to federal preemption? Far more money than \$7 billion changes hands in real estate transactions, and the current political trend is to place more power, not less, in local hands.

Maybe the federal government can lead by example. President Clinton has been asked to issue an executive order that would require the federal government to "expeditiously facilitate the location of wireless antennas" on government property. The request, contained in a letter from Cellular Telecommunications Industry Association president Thomas E. Wheeler, mentions public lands managed by the National Park Service and the National Forest Service, as well as rooftops of buildings managed by the General Services Administration (GSA).

Communications network operators already have access to public lands, so CTIA's real target must be those rooftops. "Expeditious" is the key word, because if local governments are good at delays and denials, the federal government can be a master of the game when it wants to be. Imagine how many little fiefdoms would be invaded at each federal building. Optimistically, some building managers might make life easy for network operators.

Regardless of the level of cooperation an executive order might win at each federal facility, a presidential "preemption" of GSA regulation of federal rooftops as antennas sites might give the FCC the fortitude to issue its own preemption for use with local governments.

### Telco dispatch services

The FCC has voted to lift the ban that prevents traditional telephone companies from holding licenses for specialized mobile radio (SMR) systems.

Several years ago, this move would have caused a bigger stir than it seems to be causing now. For one thing, there used to be talk of a regional Bell holding company acquiring Nextel Communications and entering the public radio communications network business. At the time, people said telcos would not be interested in acquiring SMR systems one at a time, but if a consolidator could deliver a big package of

them, that would make a difference.

Maybe the moment has passed. Cellular, the dominant wireless telephone service in which many traditional telephone companies are involved, generates \$15 billion in annual revenue. Many of the same companies are preparing to build PCS networks. SMR revenue is estimated at \$270 million, spread among about 2,500 dispatch companies. The increase in business that SMR represents today might be incremental from the perspective of the telephone companies and may not be worth the trouble.

### Bowler Foundation

Congratulations to this year's two recipients of the Bowler Award conferred April 5 by the Eugene C. Bowler Foundation, Washington, DC: Judith Dunlap, chief of the Systems Analysis Section, Office of Operations-Gettysburg, of the Wireless Telecommunications Bureau; and David Leach, a senior member of the minority staff of the House Commerce Committee.

The foundation also praised FCC Commissioner James H. Quello by giving him a Lifetime Achievement Award. Quello has been a commissioner for more than 20 years and served as interim chairman in 1993. He anticipates retiring when his term expires in June 1996.

The foundation bestows academic scholarships to students concentrating on communications law at Boston University. This year's recipients are Jason D. Oxman and H. Scott Smith, both set to graduate in 1996.

The Bowler Foundation was established in 1990 with initial funding from the Bowler family to honor the memory of Eugene C. Bowler, former chief of the FCC Private Radio Bureau's Land Mobile and Microwave Division, who died in 1985.

—Don Bishop



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- 22-25—Association of Public-Safety Communications Officials—International East Coast regional conference**, Marriott's Hunt Valley Inn, Hunt Valley, MD. Contact: Alan T. Kealey, 410-799-3466.
- 31-June 2—Radiocomm**, Toronto Metropolitan Convention Center, Toronto. Contact: 613-233-4888.
- 31-June 2—Virginia Tech Symposium on Wireless Personal Communications**, Virginia Tech Campus, Blacksburg, VA. Contact: Jenny Frank, 703-231-2958.

## July

- 26-28—Vehicular Technology Conference**, sponsored by IEEE Vehicular Technology Society, Hyatt Regency Chicago O'Hare, Chicago. Contact: Keith Paglus, chairman, 312-399-2378.
- 31-Aug. 4—Utilities Telecommunications Council**, Hyatt Regency and Convention Center, Minneapolis. Contact: 202-872-0030.

## August

- 13-18—Association of Public-Safety Communications Officials—International National Conference**, Detroit. Contact: 800-949-2726.

## September

- 20-23—Personal Communications Showcase**, sponsored by the Personal Communications Industry Association (PCIA), Orange County Convention Center, Orlando, FL. Contact: 800-326-8638.

## October

- 18-20—International Wireless Communications Expo/Fall has been canceled.**
- 26—ERA Communications Trade Fair**, Ala Moana Hotel, Honolulu. Contact: 310-287-1218.

- 29-Nov. 1—Wireless Apps**, sponsored by the Cellular Telecommunications Industry Association, The Mirage Hotel, Las Vegas. Contact: 202-785-0081.

## November

- 7-9—WirelessWorld Conference and Exposition**, sponsored by *Cellular Business* and *Mobile Radio Technology* magazines, Moscone Convention Center, San Francisco. Contact: Chris Lotesto, 800-458-0479.
- 8-12—Communications Marketing Conference**, sponsored by the Communications Marketing Association, Albuquerque, NM. Contact: Bernie Brownson, 303-371-8182.
- 17—Radio Club of America**, Communications Symposium, 86th Anniversary Dinner and Awards Presentation, New York Athletic Club, New York. Contact: Ron Formella, 201-652-6811.

## 1996

## March

- 23-25—Wireless '96**, sponsored by the Cellular Telecommunications Industry Association, Dallas. Contact: 202-785-0081.

## April

- 24-26—International Wireless Communications Expo/Spring**, Las Vegas Convention Center, Las Vegas. Contact: 800-828-0420.

## June

- 24-27—Supercomm**, sponsored by USTA and TIA, Dallas Convention Center, Dallas. Contact: 202-326-7300.

## July

- 11-13—Communications Expo/Show of the Americas**, Miami, FL. Contact: 305-229-9992.



# Mobile Radio Technology

The journal of mobile communications technology

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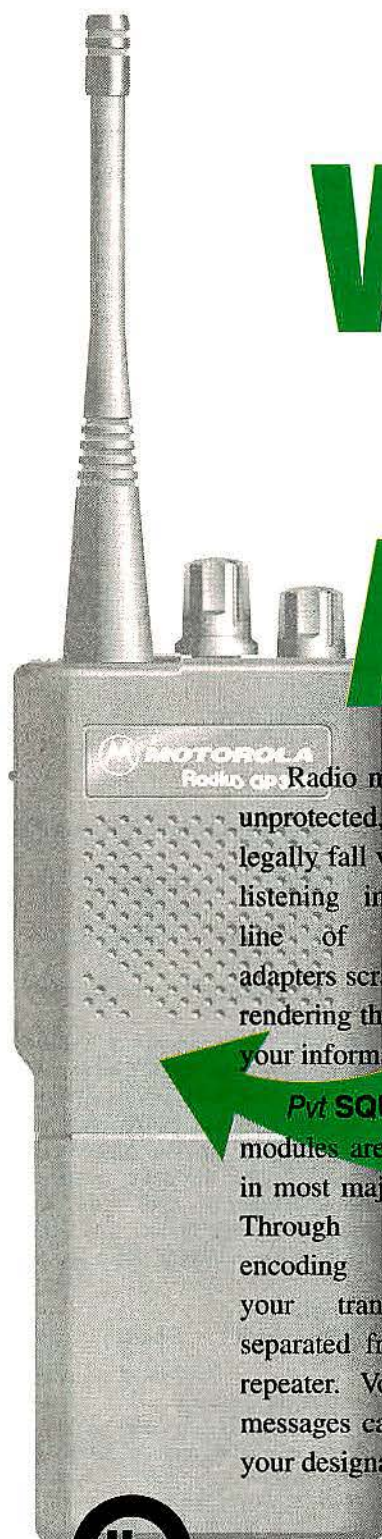
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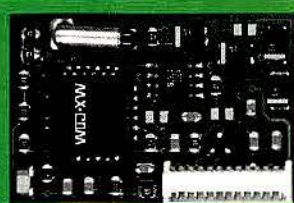
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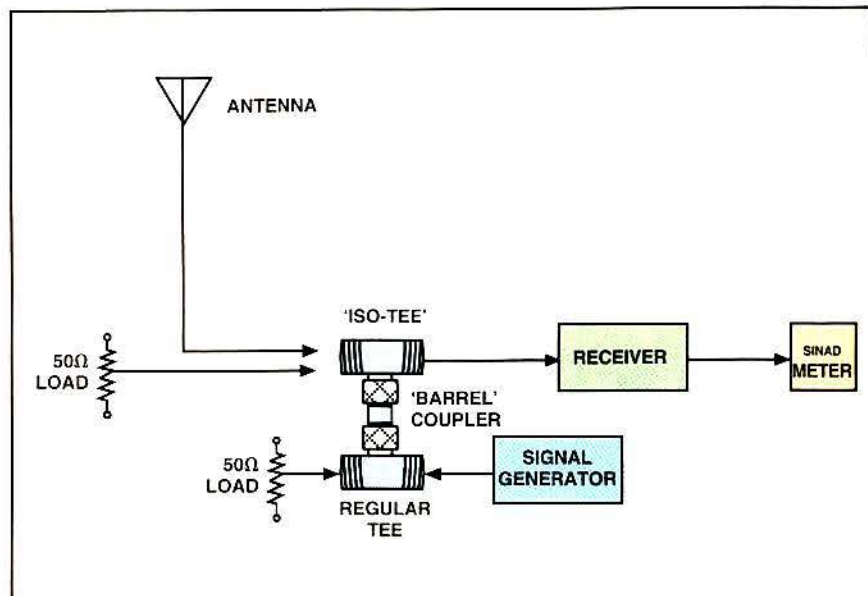


Figure 1. This setup is used to determine the effective system sensitivity. See text for details.

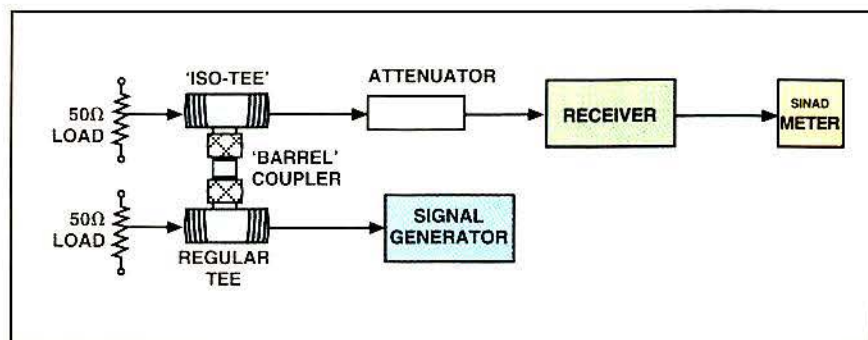


Figure 2: With this setup, the attenuator was set to zero, and the signal generator output was adjusted to produce 12dB SINAD on the receiver output.

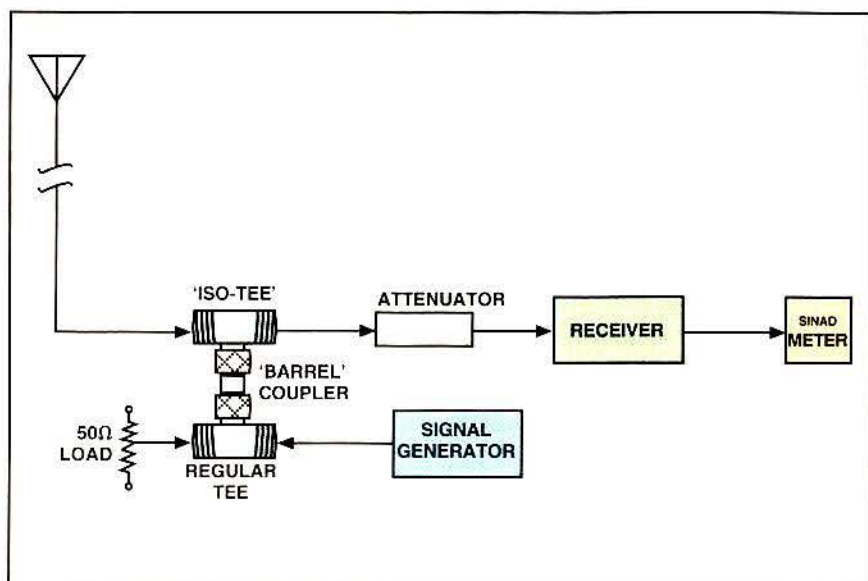


Figure 3. With this setup, the signal generator output was increased to bring the SINAD meter back to 12dB SINAD. Then the attenuation was increased until the point was reached where the SINAD reading started to degrade. See text for full details.

## Site Noise and Its Effects

By Harold Kinley, C.E.T.

As a general rule, it is important to keep communications system losses to a minimum. This objective is important to achieving maximum communications range with the available power, receiver sensitivity and antenna gain. However, there are situations in which losses do not cause as much harm to the system as one might expect. Let's look at site noise and how it affects communications—particularly receiver sensitivity.

### Bench sensitivity

When a receiver's 12dB SINAD sensitivity is tested under "bench" conditions, the receiver should meet or exceed the manufacturer's specification. However, in the real world, with the receiver connected to an antenna, the sensitivity will be degraded by the localized "site" noise. Sometimes site noise is expressed as noise "temperature." The higher the site noise, the higher the noise temperature. This can be understood by referring to the following formula:

$$E = 14.14\sqrt{KTB}$$

where

$E$  = noise voltage in microvolts (50Ω)

$k$  = Boltzman's constant, or  $1.38 \times 10^{-23}$

$T$  = temperature in degrees Kelvin

$B$  = bandwidth of receiver in Hertz.

Typically, the temperature used in the formula would be 290° Kelvin. However, site noise will almost always increase the *effective* noise temperature above 290° Kelvin. The higher the site noise, the higher the noise temperature. A noise temperature of 290° Kelvin would represent a "cool" site, that is, one with a low ambient noise level.

### Site sensitivity

Just how "hot" is a particular site? A

(continued on page 81)

Kinley, a certified electronics technician, is regional communications manager, South Carolina Forestry Commission, Spartanburg, SC. He is the author of *Standard Radio Communications Manual: With Instrumentation and Testing Techniques*, Prentice-Hall, 1985. He is a member of the Radio Club of America.



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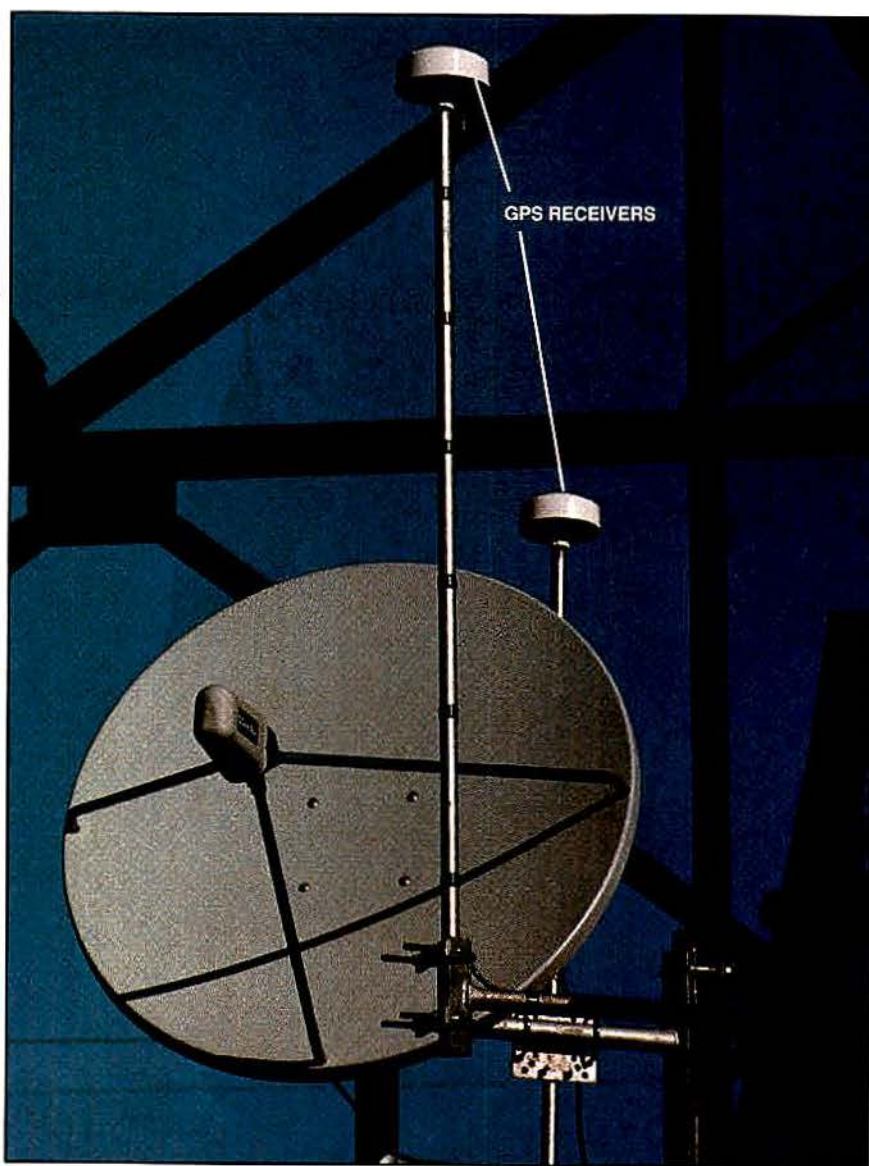
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# GPS timing signals support simulcast synchronization

*Automatic paging transmitter control uses timing signals from atomic clocks on Global Positioning System satellites to achieve precise synchronization for high-speed protocols. Resynchronization after outages is faster, too.*



These GPS receivers are mounted on short masts at the base of a communications tower in Merriam, KS. Mike Svoboda, senior technician with MobileMedia, Kansas City, MO, said the mast-mounting helps to avoid interference from transmission lines in the cable tray below.

By Al Fisch

Explosive paging industry growth caused by the ever-increasing use of conventional pagers, along with the newer, high-speed mobile computers and personal communicators, threatens to exceed the capacity of radio transmission systems to carry the message traffic.

To simultaneously broadcast (simulcast) paging messages over a wide area, paging operators use multiple transmitter sites. Unless the radio frequencies and messages are synchronized, radio-frequency (RF) interference where the signals overlap can garble the messages or prevent reception altogether.

In the past, simulcast systems used highly stable master oscillators in their transmitters to *synchronize radio frequencies*, as well as time-delay circuits to equalize phase differences and *synchronize message transmission*. Although these methods did an acceptable job in early simulcast systems, they required technicians to visit each site on a regular basis for routine and emergency synchronization adjustments.

## The need to 'get in sync'

As paging networks grow to accommodate the higher transmission speeds and longer and more numerous messages, system providers are demanding the highest possible synchronization from the least amount of technical labor. The advantages

Fisch, a journalist and marketing consultant in San Jose, CA, is the owner of Fisch & Associates. Phone and fax: 408-297-4056.

The GPS sensor mentioned in the article is the AcutimeII GPS Module manufactured by Trimble Navigation, Sunnyvale, CA. The transmitter controller mentioned in the article is the GL-C2000 control system manufactured by Glenayre Technologies, Charlotte, NC.



of automatic, tight synchronization are several.

- Potential interference in overlap areas is more predictable and controllable.
- Far less time is required to maintain synchronization, thereby increasing productivity.
- In the case of power outages, synchronization can be restored in minutes rather than hours.
- Most important, the same RF infrastructure can serve more customers, because a precisely synchronized system can use higher-speed data transmission and successfully deliver more messages and services.

#### GPS: More than positioning

Volumes have been written about the convergence of computer and wireless communications, but virtually nothing has been said about another powerful conver-

gence: RF signal simulcasting and Global Positioning System (GPS) timing technology. What is GPS, and how can it help the crowded RF infrastructure handle more and faster wireless traffic?

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*Although not yet a household word, GPS is gaining broad acceptance in a host of emerging applications.*

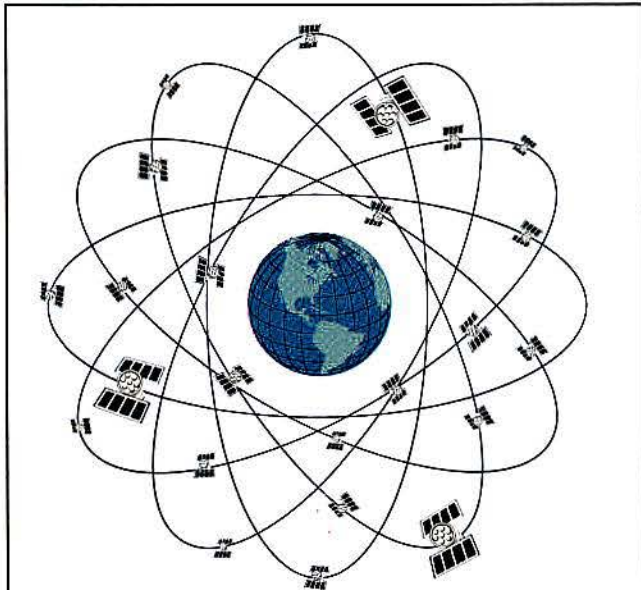
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Although not yet a household word, GPS is gaining broad acceptance in a host of emerging applications. From marine, military, aviation navigation; to surveying,

mapping and data capture; to tracking, search-and-rescue and automotive navigation, GPS receivers rapidly are making a difference in commercial and consumer electronics.

Many people heard about GPS during the 1991 Persian Gulf conflict, Desert Storm. During this massive logistical operation, thousands of GPS navigation devices helped to deploy vehicles, equipment and troops over vast expanses of desert terrain. Although Desert Storm placed GPS in the limelight by validating system performance on the battlefield, the system's constellation of earth-orbiting satellites has been operating partially complete since the early 1980s. In 1993, the 24-satellite network was completed, assuring that at least four satellites are always above the horizon, anywhere on earth, 24 hours a day.

Because all GPS measurements—



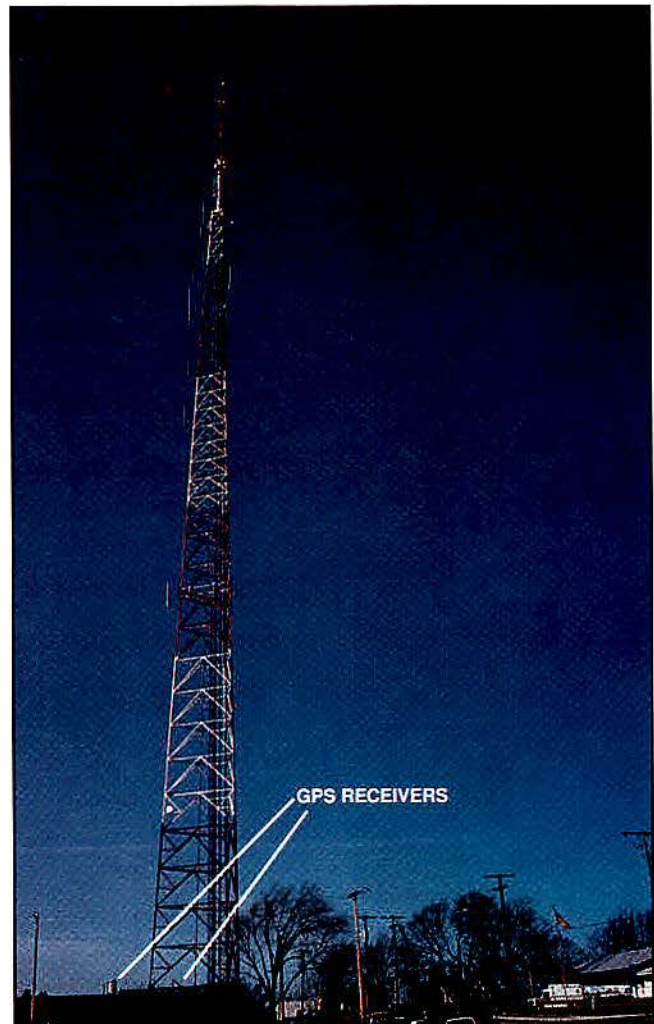
#### The basics of GPS

The Global Positioning System (GPS) is composed of 24 satellites orbiting the earth at 10,900 miles and beaming precise time reference signals to GPS receivers on earth. The atomic clocks aboard the satellites are among the most accurate time references yet developed.

From the perspective of any point on earth, at least four satellites always are above the horizon.

GPS ground receivers use these satellites as reference points for calculating their positions. The time it takes for signals to travel from the satellites to the receivers is the basic measurement. By calculating the distance (travel time multiplied by speed of light) from three known satellites, a position can be pinpointed, anywhere on earth.

A fourth satellite measurement "fine-tunes" the process. It compensates for small errors caused by atmospheric delays, as well as the lesser precision of the receiver's clock.



This picture of the entire tower puts the GPS receivers in perspective. If they were large enough to be visible in this view, they could be seen just above the roof of the building at the base of the tower. The MobileMedia paging antenna is near the top at 350 feet.



whether positional or timing—are derived from the transmitted timing reference signal, the accuracy and stability of the satellite's on-board clocks is absolutely crucial. Each GPS satellite employs four of the most accurate (and expensive) clocks ever developed. These clocks use the oscillations of a particular atom to measure time.

GPS receivers on earth compensate for timing offsets in microprocessor clocks by de-

riding time measurements from the satellites. (See "The Basics of GPS" on page 11.)

#### GPS, simulcast convergence

Although GPS was developed for an estimated \$10 billion to \$12 billion and is operated by the U.S. Department of Defense, no licensing fees are charged for commercial applications, nor is proprietary equipment required. GPS signals are available to all users on the ground, courtesy of



A closeup photo shows the GPS receiver in more detail. It can be placed in service almost anywhere there is a fairly unobstructed view of the sky.

the U.S. government.

In late 1994, GPS equipment manufacturer Trimble Navigation, Sunnyvale, CA, teamed with digital paging infrastructure manufacturer Glenayre Technologies, Charlotte, NC, to apply GPS timing technology to the synchronization of RF simulcasts. As a result, this year thousands of GPS modules will be installed on paging transmitter controllers in the United States and abroad. (See Figure 1 on page 14.)

Because the transmitter controllers receive timing information directly from the GPS satellites, no airtime is required to synchronize RF signals. This translates into 100% revenue-producing airtime for paging carriers. The GPS-based synchronization also improves simulcast performance, with fewer missed messages. After power outages, distant transmitter controllers are up and running in minutes, rather than the hours required before GPS.

#### 21st century RF infrastructure

The number of pagers worldwide is expected to grow more than 20% annually for the remainder of the 1990s, with more than 130 million units in service by 2000. Also, data transfer rates in excess of 9,600bps will be needed to handle the proliferation of acknowledgment pagers, hand-held computers and personal communicators.

The GPS sensor developed to support the necessary transmitter controller houses a GPS antenna, six-channel receiver, power supply and digital interface in a rugged, waterproof, self-contained, shielded package. The receiver tracks as many as eight GPS satellites and automatically selects the signals required for optimum timing accuracy. The output timing signal of one pulse per second is synchronized to the National Institute of Standards and Technology's Universal Coordinated Time (UTC) and is accurate

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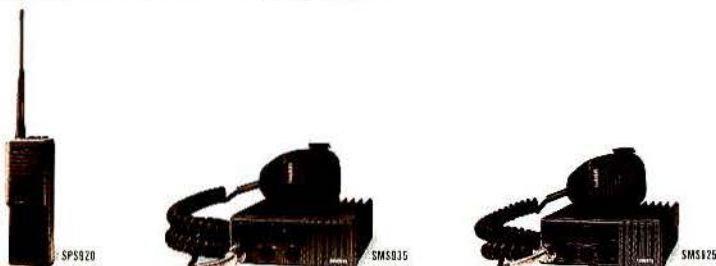


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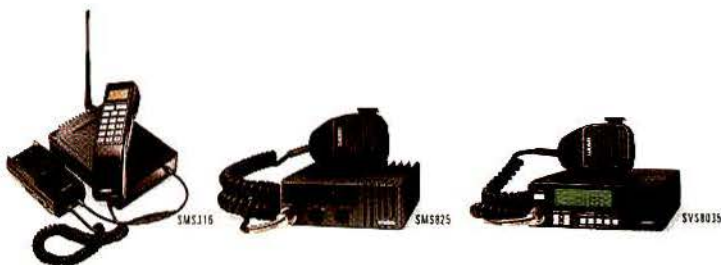
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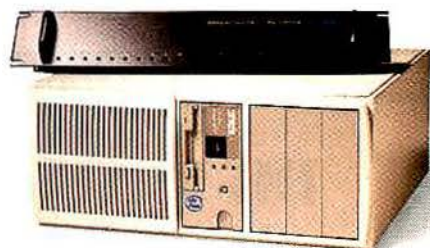


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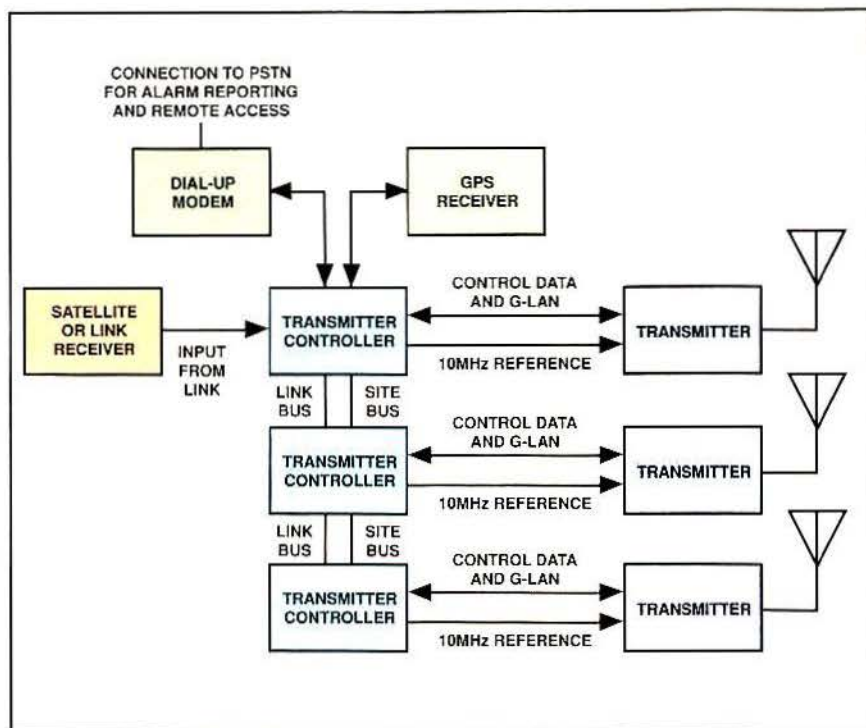


Figure 1. The GPS receiver can be shared with a number of transmitters. Using GPS timing signals, the transmitter controller can provide a 10MHz reference accurate to one part per billion ( $1 \times 10^9$ ).

to plus or minus one microsecond.

The GPS sensor supports full-duplex communications, Trimble standard interface protocols (TSIPs) with timing-specific controls and all electrical interfaces. Because the sensor is a sealed unit, installation can be performed by workers with little or no RF or GPS experience. The sensor simply is mounted on a pole, the digital cable is routed to the host system and dc power is applied. An RS-422 timing pulse supports cable runs in excess of 400 feet, which simplifies mounting the sensor on transmission towers and on tall buildings in urban areas.

The transmitter control system can mix satellite links with wire lines, microwave links and radio links. It integrates all encoding, link multiplexing and timing tasks at the link controller, eliminating the need for a separate transmitter system controller. It supports the new high-speed 9,600bps formats, recycles bandwidth and reduces hardware expense through channel-sharing. Other advanced functions include forward error-correction, automatic remote system upgrades and seamless migration from existing control packages.



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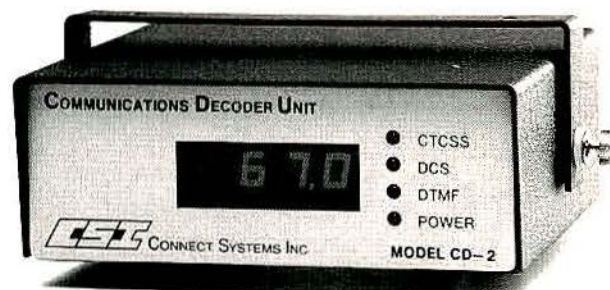
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# Coverage proof of performance: Hocus-pocus or real world?

*Part 1—Proof of performance is your ultimate target, and how the vendor chooses to get there (and still be able to sleep at night) is his problem. Here's how to tell the difference between what's important and what's not.*

By Robert T. Forrest, P.E.

Radio wave propagation is routinely misunderstood. As a result, it receives credit or blame for many radio communications systems' failures—some of which have little to do with the radio signal. You can implement a radio system without a deep knowledge of radio wave propagation physics if you focus on desired results rather than on the process of getting them.

Even the wildest stories about coverage have some basis in fact. Many people have expressed creative interpretations that sometimes defy the laws of physics! It never pays to disagree with people who describe unique situations. From their van-

tage point, they have seen and heard what they report.

Although many people are certain that radio propagation follows the *laws of physics*, to others, it frequently appears to follow the *laws of luck*. Unfortunately, you cannot afford to trust in luck when it is time to produce the proof of performance for a million-dollar communications system.

*Timing is everything.* If your system is up and running before you think about proof of performance, it probably already is too late. Think about coverage proof of performance when writing your specifications. Occasionally, a consultant is retained to monitor coverage *after* a client and vendor have signed a contract. Proof

of performance at that point is more a matter of *damage control* than of *effective enforcement*.

## Key two-way radio coverage issues

With a large, complex communications system such as many governments, utilities and industrial users are implementing, the objective is to have the vendor take full responsibility for dependable system operation.

Coverage proof of performance measurements must fit your specifications as a nut fits a bolt. Often, coverage is inadequately or insufficiently specified such that the system does not meet user expectations. In other cases, coverage is *over-specified*, which results in an overly costly system. The usual situation is that test procedures do not match the coverage specification. Tests might end up being subjective with few definitive records; they may not prove that the system performed to specification; and there may be inappropriate measurements that add cost without function.

All too often, the match between specifications, system design and proof-of-performance measurements is unsatisfactory. The specification is unwieldy and unworkable, and it requires after-the-fact interpretation. The measurement procedure is incomprehensible with no fit, and

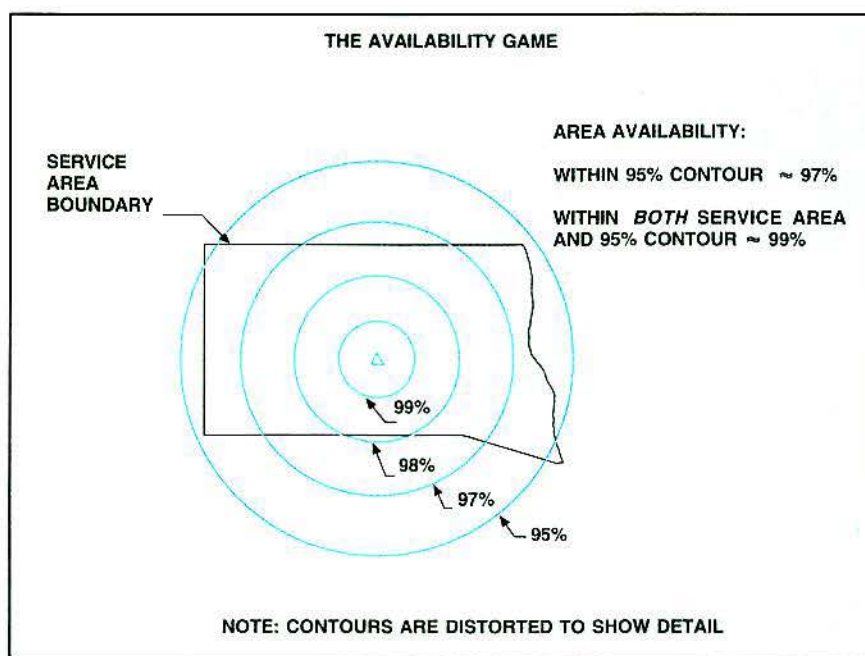


Figure 1. A typical service area and idealized circular coverage contours. This system is designed for a 95% predicted probability along the outermost contour ('contour reliability'). Note that the contour is not representative of the service area boundary.

Forrest is vice president of the Communications Technology Associates division of Hayes, Seay, Mattern & Mattern, Lynchburg, VA.

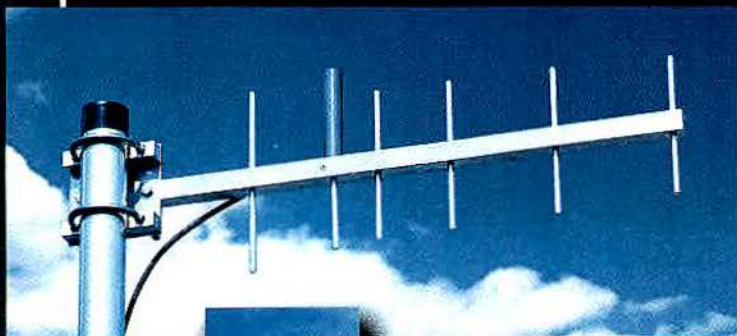
The information in this article distills nearly 30 years of experience with radio propagation; coverage predictions and testing; and dealing with vendors, clients and other consultants. With such a complex subject, there are certain to be conflicts or misunderstandings that may not be covered here. The author is interested in other points of view and may be reached at 804-239-9200.



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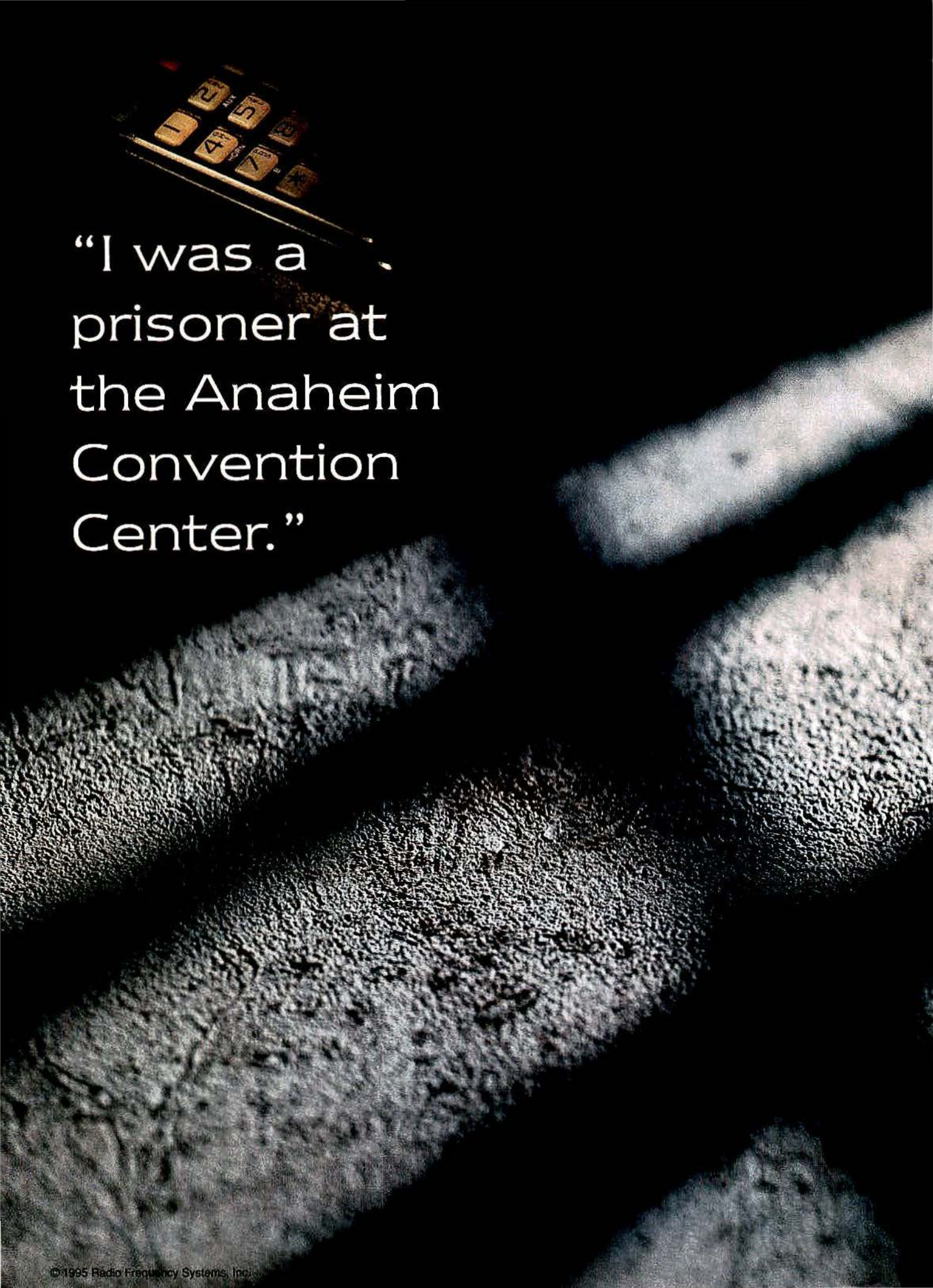
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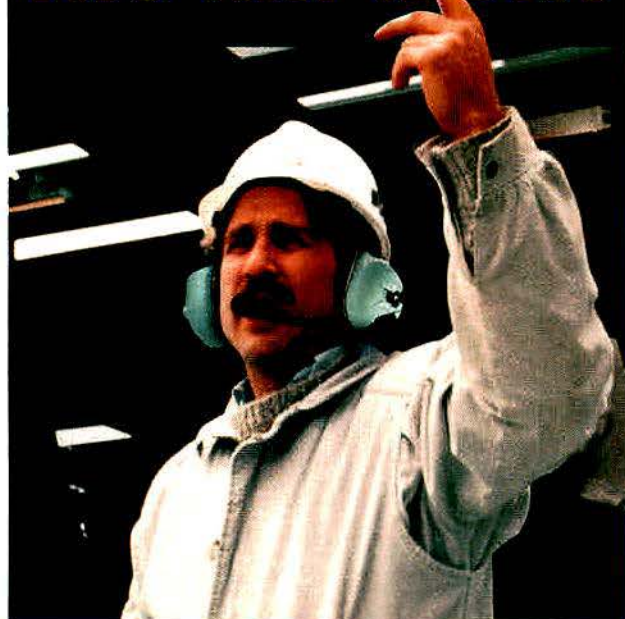
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## Developing the right specifications

Six steps are necessary for good coverage specifications:

- (1) *Analyze your needs* — Where, and under what conditions, do you need to talk?
- (2) *Make a coverage estimate* — Where can you be reasonably expected to reach with a realizable system? Is your system feasible?
- (3) *Establish the service area objective* — Where do your users actually go (a) on a routine basis; (b) on a periodic basis; and (c) on an extraordinary basis?
- (4) *Establish the availability objective* — Be realistic. Can you really tell the difference between 95% and 98% coverage?
- (5) *Establish the service grade objective* — Recognize the difference between understandability and voice quality; they are not the same. Is a system with *no noise at all* realistic?
- (6) Write a *tight proof-of-performance* specification.

## Popular coverage battlegrounds

Coverage-related confrontations, including the following, can be encountered on many battlefields:

- ☐ *The Availability Game* — Contour vs. area.
- ☐ *A Surfeit of Statistics* — 90% vs. 95% vs. 97% vs. 100%.
- ☐ *Building Penetration* — What does a 15dB building look like?
- ☐ *Time vs. Location* — vs. money.
- ☐ *Learning to Love Multipath* — Does it help or hurt coverage?
- ☐ *The Coverage Model Wars* — My circles are bigger than your circles!
- ☐ *Don't Step Outside the Circle* — The radio stops dead at the contour on the map.

## The availability game

Propagation models predict the *probability* of having a *signal level* greater than a specified number of microvolts, but proof-of-performance measurements reflect whether the signal actually is there—the *availability* of the signal.

Remember the three interrelated areas of concern in defining radio coverage:

- ☐ *Grade of service* — Described in terms of signal level, or quality of signal.
- ☐ *Service area* — Described in terms of where you need to talk, under defined conditions.
- ☐ *Communications availability* — Described as a minimum percentage of locations to and from which communications are required.



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the radio system owner is twisted and contorted in an attempt to adapt to both.

Models are designed to be specific about a particular point or a location on a map. Points with the same radio signal strength *probability* are connected to form a contour, but the vendor must guarantee *availability*, not *probability*.

The difference between availability and probability is:

□ *Probability* applies to the signal level

that is expected to be exceeded at a *particular point*. For example, at a specific location, a model will predict a 90% probability of exceeding 0.5µV.

□ *Availability* applies to the number of points at which the signal level is exceeded over a particular test area. For example, if measurements at 100 locations show that 0.5µV is exceeded at 95 of them, the test indicates 95% availability.

*Measuring along a contour is quite dif-*

*ficult*. It is nearly impossible, actually, unless the state has placed its roads precisely along that contour, which is unlikely. Even if it were reasonable to measure along the contour, the results would not represent the coverage because *such measurements would not describe what is going on inside the contour*.

Therein lies an interesting dichotomy: The *prediction* is always made using *contour probability*, and the proof-of-performance measurements are always made using *area availability*. The difference in terminology may provide an escape hatch for the vendor because *probability* is associated with a *prediction*, and *availability* is associated with *measurements*.

You are purchasing a system based on your performance expectations. Performance implies *measurements*. The specification should match the measurement process, and should therefore be expressed in terms of *area availability*.

You may have been exposed to industry rhetoric about *contour* vs. *area availability*. Let's examine the difference.

Figure 1 on page 16 shows a typical service area and idealized circular coverage contours. (Everyone knows that coverage contours are perfect circles, right?) This system is designed for a 95% predicted probability along the outermost contour ("contour reliability"). As you move toward the radio site at the center, you pass through succeeding contours, each of which represents predicted probability increases to 97%, 98%, 99% and beyond. Near the center, the probability of exceeding the target signal level is extremely high, and the "contour reliability" increases to outrageous levels.

Therefore, the 95% figure only applies to the outermost calculated contour itself. Note that the contour is not representative of the service area boundary. The "area reliability" inside the required *service area* is typically from 97% to 98% or higher. The actual number depends on a complex mathematical interaction between topography and the shape of the contour and is mostly indeterminant.

If the specifications are written in terms of coverage guarantees, enforced by proof of performance, one would conclude that the "area" vs. "contour" reliability issue is indeed rhetoric, and it becomes a non-issue.

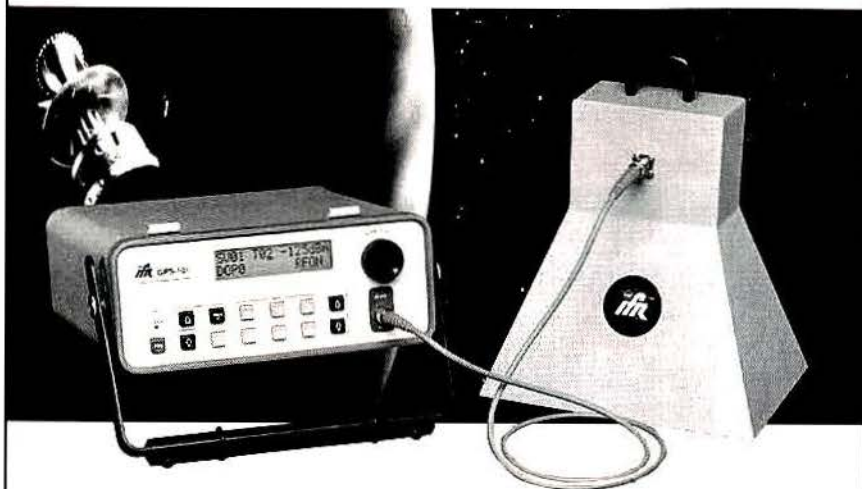
Stick with *area availability*, and you will have fewer proof-of-performance conflicts.

#### Statistics can prove anything

People often ask about a "standard" availability number for various communications systems. Should one design for 90%? For 95%? How about 98%? I have

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dBm in 1 dBm steps) and the Doppler shift ( $\pm 4$  kHz offset). The GPS-101 provides pre-programmed NAV data as well as allowing the operator to upload "user defined NAV data" via the RS-232C port. The C/A code is phase modulated, with the selected satellite (SV1 to SV37).

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found no such standard. Over time, availability numbers have increased in a progression driven in part by vendor "one-upmanship." The game is dangerous and costly, and it has inflated the numbers beyond those dictated by practical needs. Historically, this process has been true for public safety, and it is becoming true for systems in general. We have implemented systems at 95%, and users have considered them adequate. We also have implemented

systems at 90%, and users have considered them adequate. Availability statistics have many of the aspects of a poker game.

In the past, vendors have blithely promised high availability figures. Those same vendors balk at specifications that require that they *deliver* a system that provides the required availability under controlled measurement conditions. Enforcing the coverage provisions of our specification represents a significant part of our effort during

the proposal evaluation, contract negotiation, implementation and acceptance phases of our projects. This enforcement is especially important with large, complex, multisite 800MHz trunked systems covering a wide area.

The rules of statistics, as applied to coverage, are simple:

☐ If your new system provides the required coverage over 95% of your area, and the previous system covered inside the cafeteria at your main office (and the new one does not), you have effectively missed your coverage requirement.

☐ If your new system tests out at providing 97% coverage, and your operations vice president cannot reach you via his portable two-way radio while standing next to his bed, you have effectively missed your coverage requirement.

☐ If the mayor cannot monitor the police channel on his scanner, the percent availability delivered by the system is moot.

The numbers in themselves have little meaning and have less impact than *perceptions*. They are an engineering tool used to ensure that the system is designed reasonably and that you have a test basis for acceptance.

Remember also: There is *no such thing as 100% coverage*, and anyone who tells you different is suspect.

#### A 15dB building?

Public safety users are especially concerned about building penetration by radio signals. Practicality, though, demands that the buildings be matched to what you can expect in your area. It is essential to verify that the vendor can perform proof-of-performance measurements in a reasonable fashion without entering every building.

Typical building penetration "rules of thumb" are:

- ☐ Residential frame buildings: 2dB.
- ☐ Moderate, two-to-four-story office buildings: 10dB.
- ☐ Heavy downtown buildings: 25dB.

Most radio penetration is through the windows, so 800MHz penetration losses are somewhat less because of shorter wavelengths. Forget guaranteed coverage into bank vaults, elevators, prisons and many underground parking garages unless special design configurations are used.

Test the coverage using a mobile radio unit, adjusting the measured signal level for building penetration and derating the measurement for portable radio efficiency.

#### 90/90 specification

Do you want coverage 90% of the time in 90% of the area? Give me 90% of your money.

Writing a two-way radio coverage

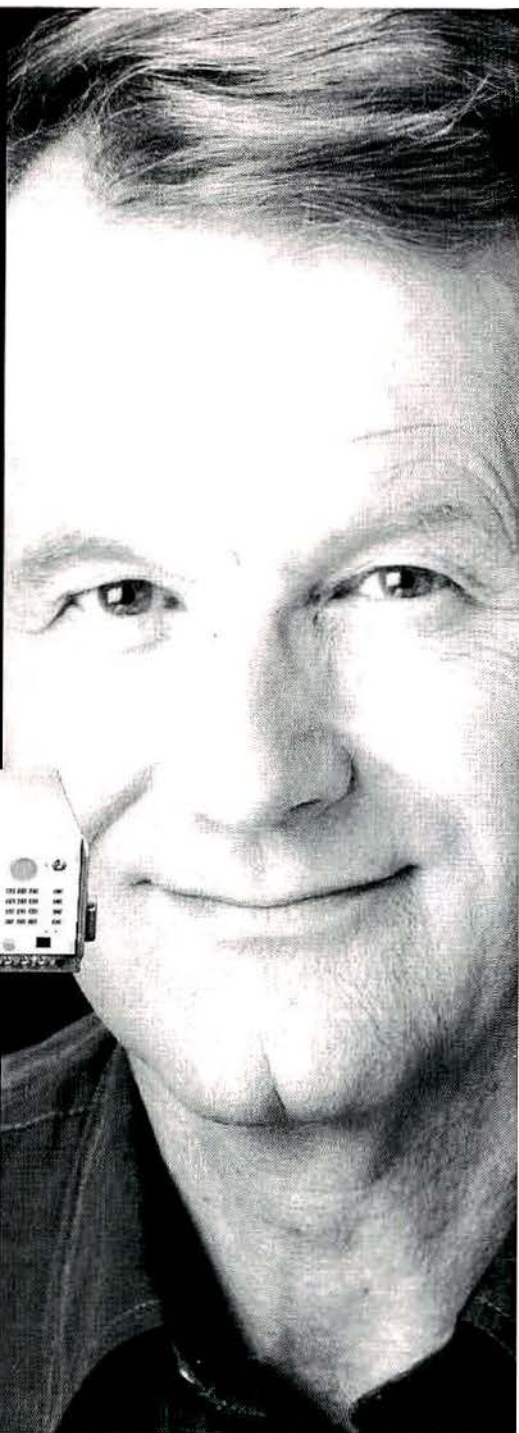
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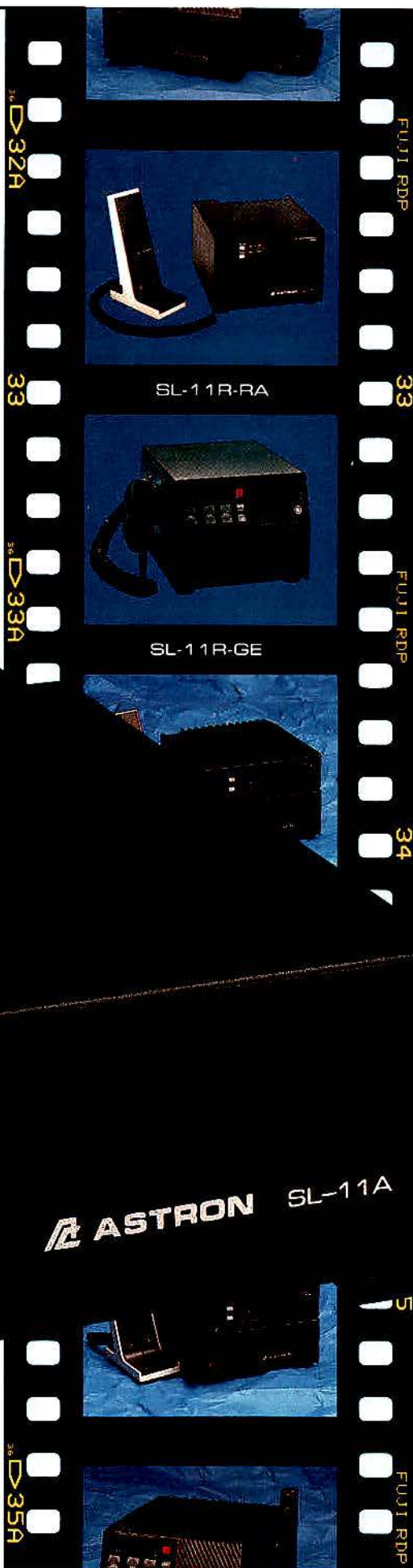
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specification that mixes time and area availability is simply poor engineering. It is ill-defined and unmeasurable. A time-availability specification is better suited to microwave point-to-point paths. Combining time availability with area availability, which is a mobile specification, serves both mobile and fixed applications poorly. The best example of how a time-and-area specification affects your system guarantee is to look at how the mix might be

interpreted from three perspectives. (All three interpretations have been tried on me at one time or another.)

□ The *vendor* might interpret a 90/90 specification as meaning that 90% of the area will meet the specified grade of service 90% of the time. To him this means that if the test is acceptable at  $90\% \times 90\% = 81\%$  of the locations, it has passed.

□ The *owner* might interpret a 90/90 specification as meaning that no more than

10% of the area may fail to meet the specified grade of service more than 10% of the time. To him this means that only  $10\% \times 10\% = 1\%$  of the locations will be allowed to fail.

□ The *engineer* (needing some training in statistics) may have assumed that the specification applies to an average; therefore, he expects that  $90\%$  of the area +  $90\%$  of the time  $\div 2 = 90\%$  of the locations must pass.

I maintain that a test proving 90/90 coverage would require measuring at least 100 points throughout the service area on at least 100 days. On at least 90 of those days, 90 of the points must pass the test. You can easily see this is an unworkable test.

The answer remains: Stick with area availability *only*.

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ways that cause it to reach a receiver via multiple paths. The receiver, in effect, picks up multiple signals that may, at any given time and position, make reception stronger or weaker than it would be via a single path. Multipath perceptions are widespread and are usually wrong. The vendor may say that multipath is *great* because it "fills in" behind buildings.

Users may say that it is *lousy* because it "breaks up" their signal at the fringe areas. Multipath is simply *always* there, and it neither helps nor hurts. It is a fact of life.

Multipath (Rayleigh fading) at the service area fringes has a minimum effect on analog signal *intelligibility* if the *median* signal level stays above 20dB of quieting.

The effect is different for digital signals and is addressed by vendors differently depending on their approach. Generally, a good analog design will deliver an adequate digital signal; nevertheless, there is a significant difference in the way that a digital signal is *perceived* at the fringe area. Do not expect it to sound the same as a fading analog signal.



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Table 1—Common propagation models.

MODEL	DESCRIPTION
Bullington	Free space, plane earth • conservative, most accurate for low frequencies
Egli	Empirical improvement on Bullington • adds reliability factors
Carey	Based on measurements made for television • FCC uses Carey for 800MHz • not considered particularly accurate
Longley-Rice	Analytical, uses ray theory • requires computer • developed by National Institute of Standards and Technology
Okumura	Empirical, very popular • measurements made in Japan • needs computerized version

Simulcast multipath may appear to be more severe than single-site multipath. You will be able to discern multipath in high signal level areas. I have never found it to interfere with *understandability*, though.

Accommodate multipath, and learn to live with it.

#### Propagation models

"My circles are bigger'n your circles."

Arguing about models is futile. For the more technical reader, a review of the IEEE VTG transactions issued February 1988 describes the various models in use. Table 1 above summarizes them.

All of these models are very good—and all of these models are very bad. I ascribe about 50% of the ability of a model to accurately predict coverage to the model itself, and the other 50% to the ability and

experience of the engineer using the model. This opinion may be bad news to people whose confidence in computers and models is credulous. A healthy dose of skepticism in computerized propagation models is wise unless you know the engineer well.

As an aside, vendors use different combinations of these models, and indeed they produce different results with the *same* data. One model is not any more *accurate* than another, just . . . different.

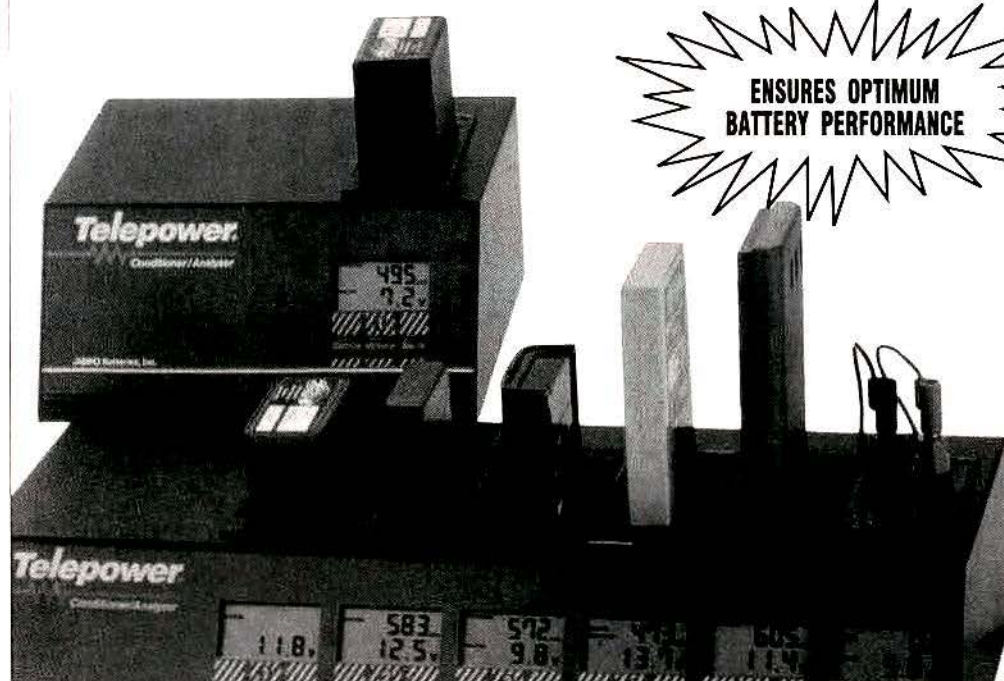
*Important:* If you focus on proof of performance as your specification criterion, the model's accuracy is now the problem of the vendor guaranteeing coverage, not your problem. A well-written specification makes the vendor's coverage map academic. That is not to say that you should ignore the model and the vendor's maps. Be sure he has done his homework and his system is realistic. Evaluating vendors by coverage maps, though, is asking for trouble.

#### Beyond the contour

Some otherwise perfectly intelligent people are convinced that the radio wave stops dead at the contour on the map. They

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# IS THERE LIFE ON THE OTHER SIDE OF THE CONTOUR?

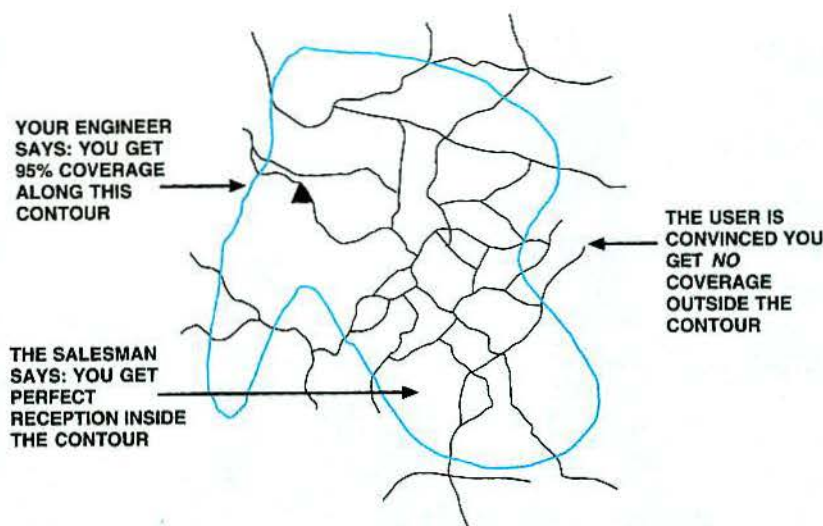


Figure 2. Coverage prediction is an approximate science, statistical in nature. A 95% contour contains dead spots, and a good signal may be heard at some locations outside. Do not expect other people to believe it, though. They have, after all, seen the contour map, and they are now experts.

are also convinced that the more *irregular* the contour, the more accurately it describes these absolute limits of coverage. Therefore my admonition: *Never draw circular contours!*

Remember that coverage prediction is an approximate science, statistical in nature. A 95% contour will contain dead spots and will deliver a good signal at some locations outside. Do not expect other people to believe it, though. They have, after all, seen the contour map, and they are now experts. (See Figure 2 to the left.)

## Service probability

Here is an uncomfortable fact about coverage predictions and statistics: even if a model perfectly reflects the laws of physics, it is never right! Put another way, if 100 systems are designed using a particular model, 50% of them will (when measured) exceed the prediction, and 50% will fall short. None of them will be right on. Thus, the *laws of physics* are subverted by the *laws of statistics*, a sad state of affairs for engineers.

Obviously, this fact causes heartburn for propagation engineers who are rightfully concerned that their \$15 million system design has a 50% chance of failing the proof-of-performance test.

The best way of improving the odds is to apply a perfectly valid statistical parameter called the "service probability." This parameter is a carefully derived and well-documented fudge factor that allows the vendor's engineer to coexist with his salesman. It may be called by different names such as "foliage loss" and "system variability."

Use of the service probability factor is the vendor's call. Remember that proof of performance is your ultimate target, and how the vendor chooses to get there (and still be able to sleep at night) is his problem.

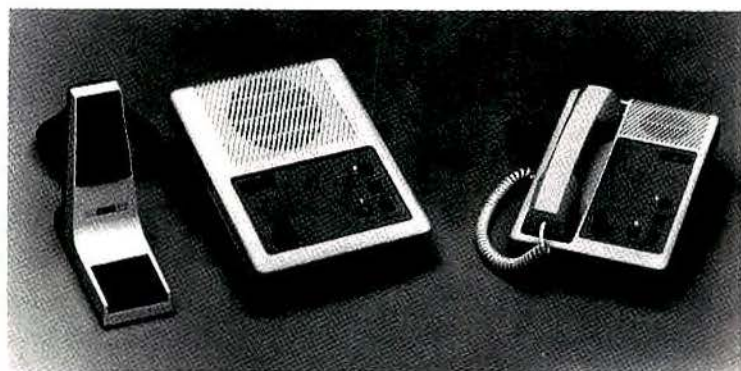
*Next: details about the three performance specifications: grade of service, service area and availability.*

## References

1. Forrest, Robert T., "Common Radio Propagation Modes in Plain English Series," *APCO Bulletin*, May 1991, pp. 56,64; June 1991, pp. 77-78; July 1991, pp. 52,54; November 1991, pp. 46,49; April 1992, pp. 54-56; May 1992, pp. 46-47.

2. "Coverage Prediction for Mobile Radio Systems Operating in the 800/900MHz Frequency Range," special issue of *IEEE Transactions on Vehicular Technology*, February 1988.

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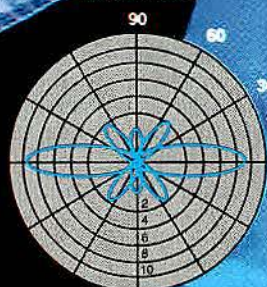
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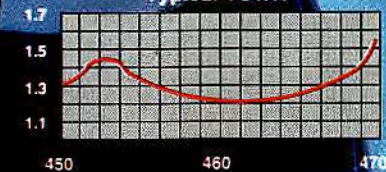
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# Mesa, AZ, tests quasi-synchronous simulcasting

*RF carrier frequency control, audio phase differences and audio amplitude differences greatly affect simulcast systems. Phase and amplitude, the most difficult to keep under control, have been tamed by a PC-based system.*

By Don Pfohl

In Spanish, "mesa" means "table" or, geographically speaking, "a flat space"—which pretty well describes the land near Mesa, AZ.

The relatively flat valley floor would seem to indicate few radio wave propagation problems, and that is the case—outdoors, but inside shopping malls, parking garages, office buildings and manufacturing facilities, two-way radio communications suffers. Delivering indoor reception is important to provide portable radio communications with many of the city's 2,800 employees.



These pictures show the quasi-synchronous system equipment at the Mesa Communications Center (left) and at Mesa Community College, one of the repeater sites. Figures 1 and 2 show the geographic and electronic configurations for these sites.

In 1984, the city began to develop a simulcast system to deliver radio signals strong enough to penetrate buildings throughout Mesa. Because not enough radio frequencies were available to serve Mesa's 125 square miles and multiple city departments by sectors, simulcasting appeared to be the only appropriate technology.

By 1986, the major problems had been solved. Five transmitter sites using VHF highband and UHF frequencies were being configured for simulcasting. The VHF system worked satisfactorily, with reservations. Even with steps taken to stabilize the system despite temperature and voltage excursions, the VHF system was expected

to require frequent realignment. Unfortunately, the UHF simulcast system was not acceptable because it could not be adequately stabilized. Simulcasting at UHF was abandoned.

To reveal locations with weak UHF reception, the division ran a comprehensive field study of radio coverage from several sites. Perhaps a single site could deliver a signal strong enough for portable radio use indoors. The result was negative. More than 100 locations out of 600 that were measured received signals that were too weak. The original reason for simulcasting remained, but an economical and stable simulcasting method solution was elusive.

The city's work with 450MHz simulcasting revealed the difficulty in obtaining precise control of differences in audio phase and amplitude on radio signals received in overlap areas between transmitters.\* Overlap areas are found where two radio signals are received at about equal strength, allowing the receiver to process both signals. Unless the signals have nearly identical RF carrier frequencies, audio phases and audio amplitudes, the listener may hear unacceptable noises and distortions.

The Mesa system uses a continuous-tone controlled squelch system (CTCSS) to mute some kinds of noise and interference. With the 1986 UHF simulcast system, differences in audio phase or audio amplitude on the CTCSS tones created continuous

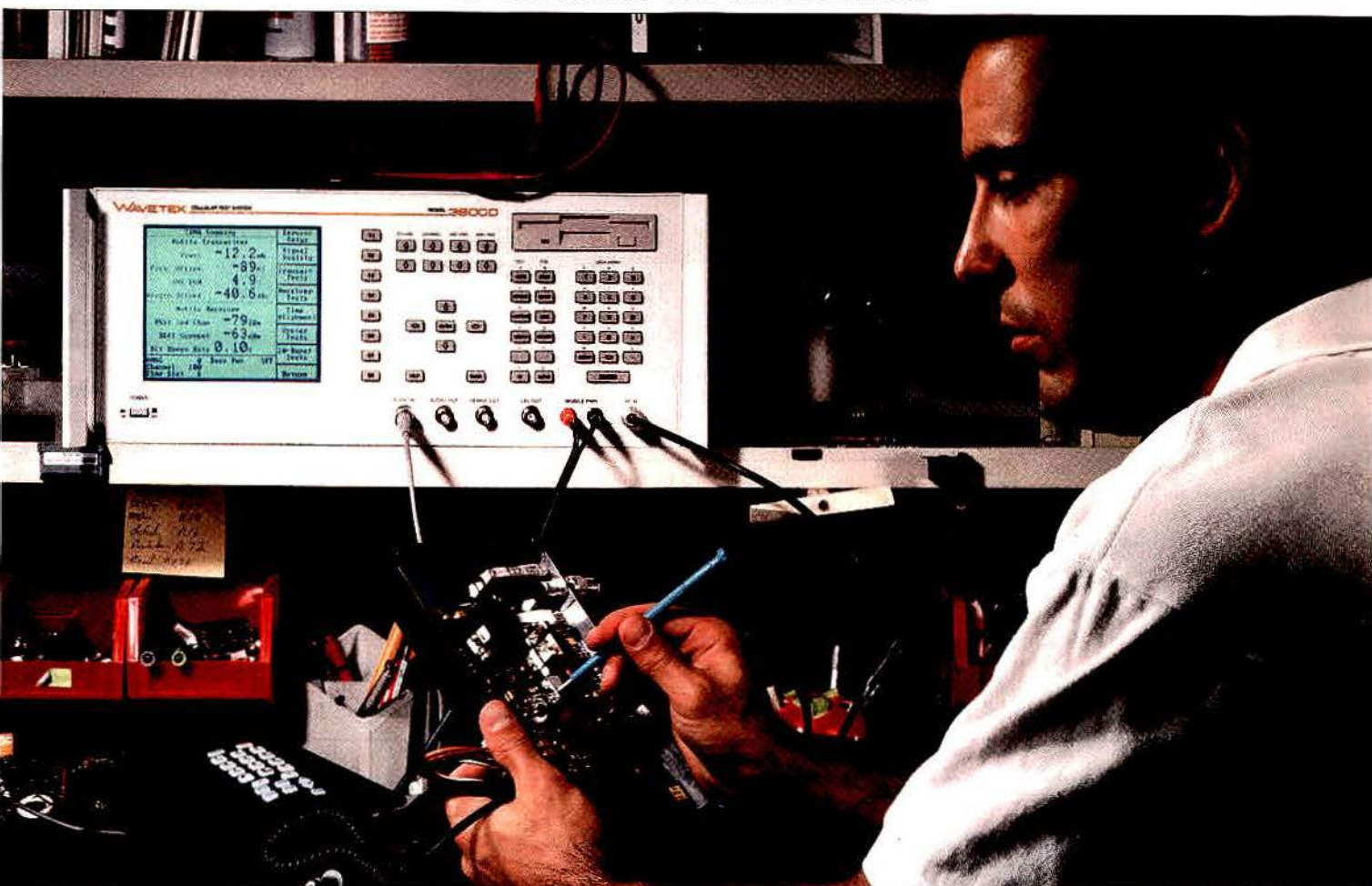
\*A third element of successful simulcasting, RF carrier frequency control, was not an issue for Mesa, AZ, because the RF carrier frequency control equipment it acquired in 1986 was adequate. The same equipment was used in the 1994 quasi-synchronous simulcast system beta test.



Pfohl is communications director, City of Mesa, AZ. The quasi-synchronous simulcasting system described in this article is supplied by Tait Electronics U.S.A., Houston.



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distortion and noise on the received audio.

► **Audio phase** — Audio must be carried from the central location to each simulcast transmitter. Audio traveling by paths of different lengths reach the transmitters at slightly different times or *time delays*. Identical except for their audio time delays, two radio signals received in the overlap zone have audio *phase differences* that cause distortion. The time difference must be corrected by adding delay to the signal at the closest transmitter to equalize its audio phase with signals coming from more distant sites.

► **Audio amplitude** — Because different media or paths may distribute the audio to separate transmitter sites, the audio quality reaching each transmitter may differ slightly. To match the audio reaching each transmitter more closely, the audio's *amplitude*, in addition to its phase, must be controlled. Experience shows that simulcast system audio ampli-

tude must be controlled within 1dB from site to site. Maximum phase error with CTCSS is as little as 7° to 10° where a

continuous tone is present and not much more than that for speech. The key, though, is not in *achieving* this precision, but in *maintaining* this precision, at a reasonable cost.

In 1993, the author, Don Pfohl, read about a simulcast technique that uses an IBM-compatible personal computer to tune audio amplitude and audio phase automatically. A test of the quasi-synchronous system at Mesa was arranged to see whether it could control phase and amplitude closely enough to carry CTCSS tones without causing distortion and noise.

### Quasi-synchronous simulcasting

With the quasi-synchronous simulcast system, the communications center audio is divided into as many outputs as there are transmitter sites.

Each audio output is equalized for phase and amplitude before being fed to each link input to the remote sites. Properly

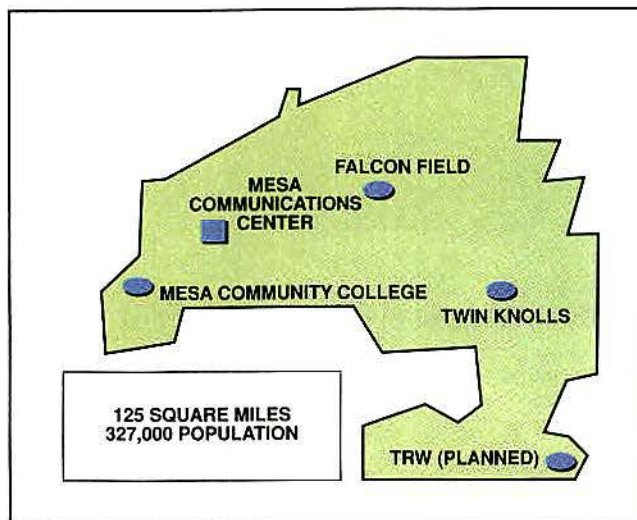


Figure 1. Quasi-synchronization simplifies equalization because all transmitters may not necessarily have to be equalized with one another. In the Mesa, AZ, system, for example, the Mesa Community College and Falcon Field transmitters are equalized, and the Falcon Field and Twin Knolls transmitters are equalized. Signals from Mesa Community College and Twin Knolls do not overlap, so those transmitters do not have to be equalized.

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- CTCSS can be held off before and during ANI
- Each memory location can have different CTCSS and/or DCS for encode or decode
- Emergency ANI with repeat delay timer
- Accidental "man down" warning tone timer
- High-pass filter for removing tones from receive audio signal

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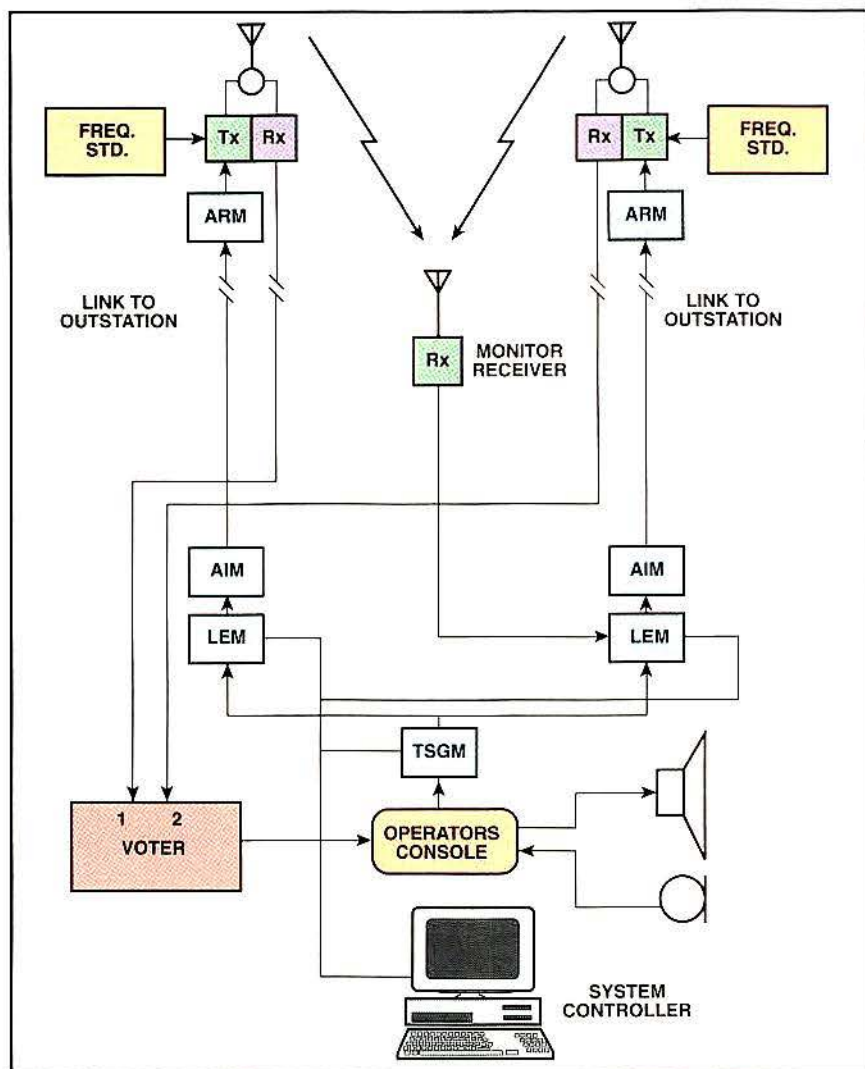


Figure 2. The quasi-synchronous system controller in the equipment room at Mesa's communications center connects to the communications dispatch consoles. Only the system controller software is proprietary. It controls the "training" process required to calculate equalization for each site. The hardware is any IBM-compatible PC.

equalized audio signals received in the overlap zone are combined in the mobile receiver, resulting in enhanced signal reception. Without proper equalization, the resultant received signal could be noise, distortion or silence.

Virtually any links, such as telephone lines, twisted pairs or RF links, can be equalized. A different medium can be used for each link. The only difference is that the more stable the link, the greater the interval between automatic system tests. In the Mesa system, the links from the communications center to remote sites are digital microwave links.

"Quasi-synchronous" means not all transmitters must be synchronized to a single reference, as found with most other simulcast systems. It is only necessary to synchronize overlapping transmitters. The word "quasi" implies that there is no single system reference.

In the case of Mesa's three-site system, Figure 1 on page 36 shows the location of the transmitters. Signals from Mesa Community College (site 1) and Falcon Field (site 2) overlap, as do signals from Falcon Field and Twin Knolls (site 3). Signals from Mesa Community College and Twin Knolls do not overlap. As long as overlapping signals from site 1 and site 2 are equalized and overlapping signals from site 2 and site 3 are equalized, it does not matter whether signals from site 1 and site 3 are equalized. This "quasi" synchronous condition simplifies equalization. It allows computing a closed-form solution based on reception monitored by a receiver. Ideally, the receiver should be located in the overlap zone.

A closed-loop technique measures test-signal audio received in the overlap zone. The results are used to compute the equalization required to match audio phase and amplitude for the two overlapping signals.

The quasi-synchronous system controller in the equipment room at Mesa's communications center connects to the communications dispatch consoles. (See Figure 2 above.) Only the system controller software is proprietary. It controls the "training" process required to calculate equalization for each site. The hardware is any IBM-compatible PC.

#### 'Training' the system

"Training" refers to the process whereby



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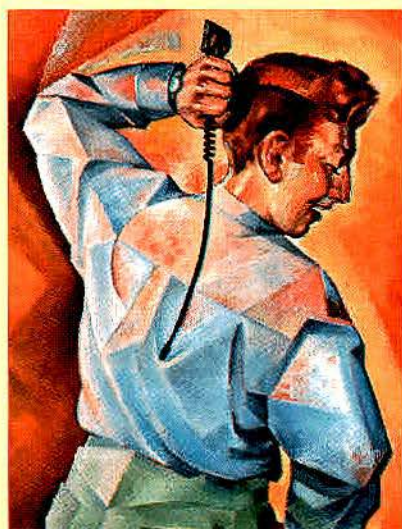
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each transmitter is tested with an audio band sweep signal. The results of the transmissions are combined for overlapping transmitters to compute the necessary equalization.

Communications consoles provide transmit audio directly to the test signal generator module (TSGM). Because Mesa's radio system uses CTCSS, the TSGM adds the CTCSS tone to the voice audio and sends these combined audio sig-

nals to the line equalizing module (LEM).

The TSGM, aside from injecting the CTCSS tone, is passive to the transmit audio signal and provides no processing. Only when activated by the system controller according to a customer-selected schedule does the TSGM generate test signals to optimize system performance. To avoid interfering with the system operation and to avoid miscalculating any of the signal characteristics, testing is planned for

a normally quiet period. When the system is in training mode, the monitor receiver should not be subject to interference or a noisy signal from the transmitter under test. Therefore, in Mesa, testing is performed at 3 a.m. on Sundays.

Voice audio with CTCSS from the test signal generator module is connected to each line equalizing module in the system, one for each transmitter. That signal is first digitized by the LEM. Then, the digitized signal is "processed" or modified based on a set of audio frequency dependent limits calculated by the LEM during the system's last "training" session. These limits compensate for transmission path errors in the audio amplitude and audio phase across the audio band.

To calculate the audio frequency characteristics, each LEM, when ordered by the system controller, enters the "training" mode. An audio signal that sweeps the audio band from 67Hz to 2,550Hz in 48Hz increments is generated by the TSGM.

To cause the signal received in the overlap zone between Mesa Community College and Falcon Field to have the same phase and amplitude, one of the sites is designated as the "reference" site—Mesa Community College, for example. All other transmitters in the system are turned off for this test. Results of the test signal received from the reference site by the monitor receiver are cataloged by the controller.

Then, the Falcon Field transmitter is activated while all other sites are inactivated. The results of the Falcon Field test signal are recorded by the LEM, thus producing two sets of data, one each from Mesa Community College and Falcon Field. The changes in audio characteristics that are necessary to make the signal from Falcon Field resemble the signal from the reference site are then computed.

One critical element in this process is that the signal to the monitor receiver must be strong enough so that the system controller makes decisions based only upon valid recovered audio signals and not upon audio plus noise. When the signals from both transmitters are adjusted to match each other, the mobile receiver will see a composite audio signal made from multiple audio signals that are in phase and that have equal amplitude across the audio band. When this condition is achieved, the received audio is actually enhanced compared to audio from a single transmitter.

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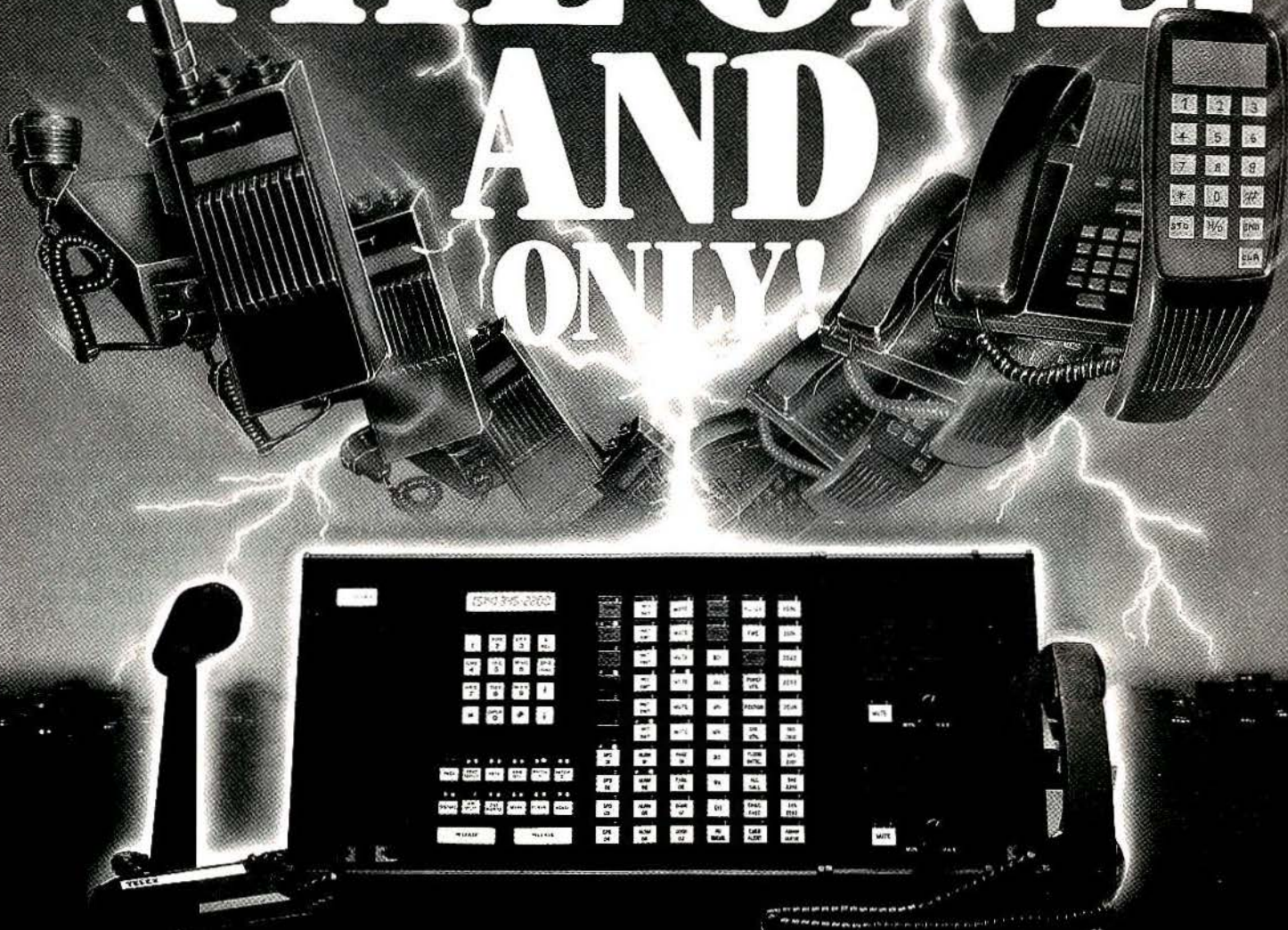
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difficult. In the overlap zones, phase differences between the CTCSS tones from two transmitters created a buzzing sound in the receiver that could drown out a voice.

The quasi-synchronous simulcast system uses a processing module pair at the communications center and at a remote site to handle CTCSS tones. At the communications center, an audio inversion module digitizes the transmit audio and the CTCSS

tone sent from the line equalizing module.

Before the audio signal is sent to the transmitters, the entire audio band of frequencies is inverted and shifted above 300Hz. Low frequencies are now in the upper end of the audio signal on the linking medium, and the higher frequencies are now in the lower end of the 300Hz-3,000Hz bandwidth.

Because of the audio band inversion, what ordinarily is a low-frequency

CTCSS tone (100Hz for Mesa) is placed in the higher end of the link audio band between 2,550Hz and 2,850Hz. Because of this inversion, the CTCSS tone is not lost when it is sent over a telco line or microwave system, and program or wide bandwidth channel equipment is not needed.

By digitizing the audio band and inserting a 2,970Hz pilot tone as a reference, the audio inversion module protects against phase shifts and amplitude errors. Such errors can occur when FM radio signals are transmitted through a noisy environment. At the remote site, the audio recovery module reverses the inversion and recovers the audio signal and the CTCSS tone intact. Because the signals were carried as digital signals, phase and amplitude errors are minimized.

#### Questionnaire

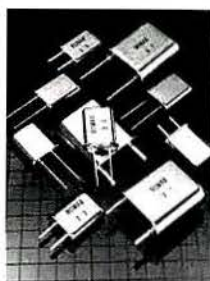
During the initial system setup and before the acceptance of the system, the city's utility department users were asked to fill out a subjective questionnaire daily to determine whether changes to the system were having a positive or negative effect on how it sounded. This analysis helped to reveal whether progress was being made.

A more objective measure was the computation and capture of various radio signal characteristic values obtained during the training process. If the system had stabilized, the values of the characteristics would stabilize, too. That is, the measured characteristics would tend to settle toward a set of values that would represent optimum performance. At the outset, the quasi-synchronous system was trained twice a day, and the characteristics were printed each time. The reason for training this often was to capture a large amount of training data quickly.

Once the history of the training sessions indicated that the system had stabilized, a 30-day test was initiated. City officials wanted to see whether the system would remain on its automatic training schedule and remain operational without intervention. If the system could hold the operating characteristics within an acceptable range, the city would accept it as operational. Having met that condition, the Mesa system has been operational since June 1994.

Today, the number of training sessions per week has been changed from twice per day to once per week. City officials believe that the system could accommodate even fewer training sessions, but the test does not affect system operation, and it is automatic, so there is no reason to change the interval. The system controller software

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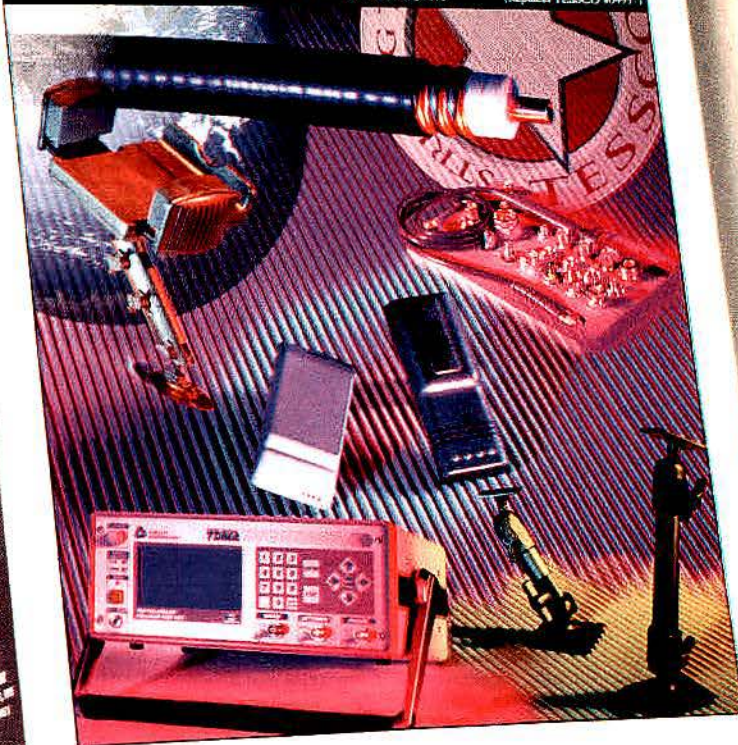
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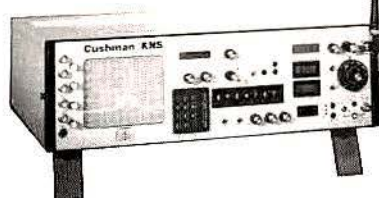
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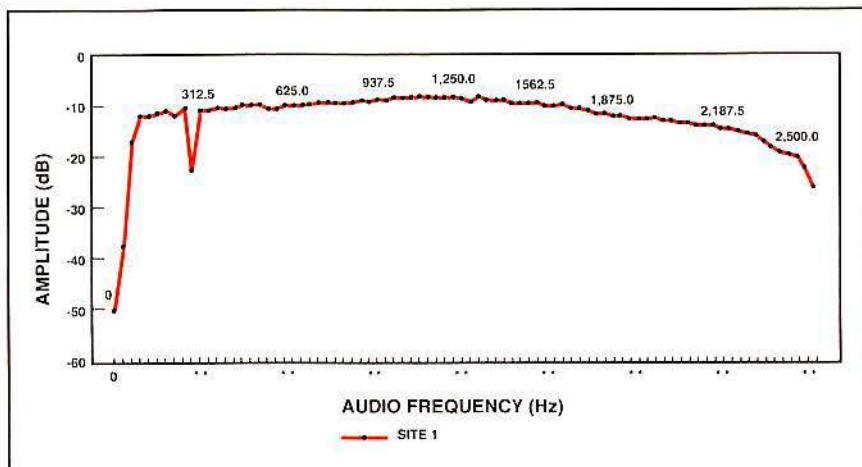


Figure 3. A typical audio frequency response measurement for Site 1.

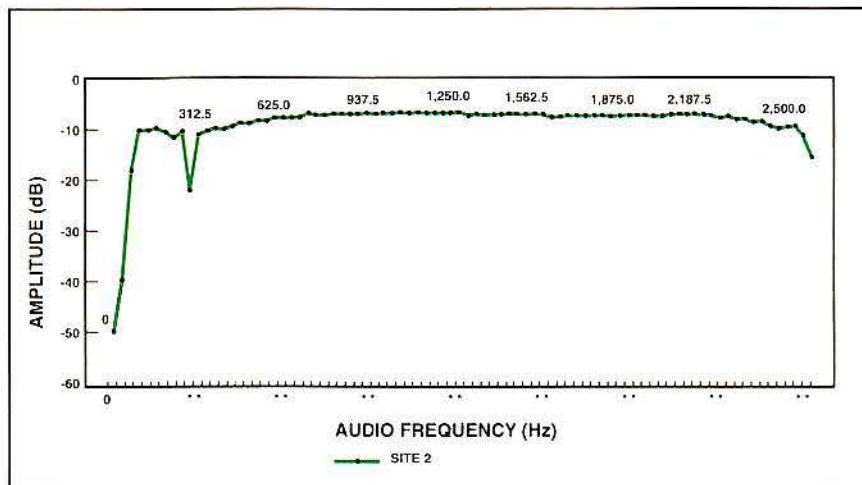


Figure 4. A typical audio frequency response measurement for Site 2.

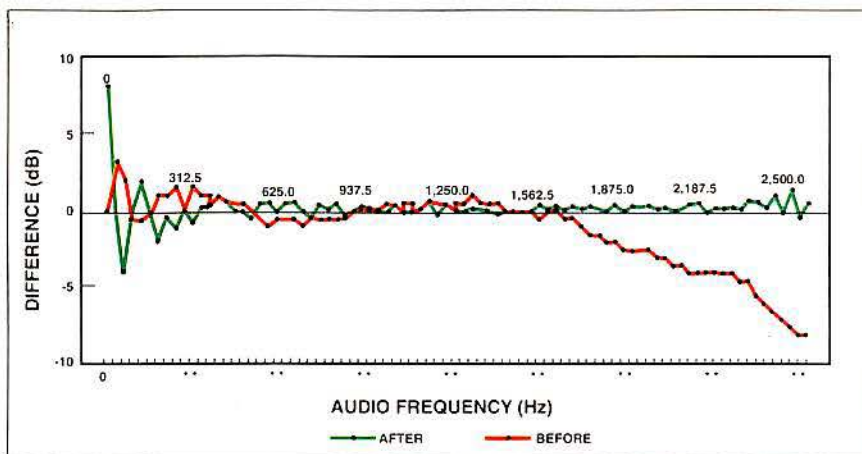


Figure 5. Looks are deceiving. Although Figure 3 resembles Figure 4, if you subtract one graph's values from the other's to chart the difference, the result is shown by the curve depicted using the dots on the red line above. The differences in this example exceed the 1dB tolerance for audio amplitude differences allowed for successful simulcasting at many points along the curve. The dots on the green line depict the difference curve after the quasi-synchronous simulcast system had computed the necessary changes in operating characteristics and had reset the system for correction. The differences have been reduced to the 0.25dB-0.5dB level, well within the requirement for simulcast operation.



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A typical audio frequency response measurement is shown for Site 1 in Figure 3 on page 44. It resembles the frequency response for Site 2 shown in Figure 4 on page 44.

Looks are deceiving. If you subtract one graph's values from the other's to chart the difference, the result is shown by the

curve depicted using the red line in Figure 5 on page 44. The differences in this example exceed the 1dB requirement at many points along the curve.

On the same chart, the green line depicts the difference curve after the quasi-synchronous simulcast system had computed the necessary changes in operating characteristics and had reset the system for correction. The differences have been reduced to the 0.25dB–0.5dB

level, well within the requirement for simulcast operation.

#### More simulcasting in Mesa?

Because this system was a beta test, it was Mesa's option whether to do more with the system beyond accumulating experience and knowledge. In fact, the city purchased the system and has been using it for months. The city is considering whether to convert additional radio channels to the quasi-synchronous simulcast system.

If Mesa decides to add sites or channels, these additions will be within the capacity of the system controller software. The software can support as many as eight simulcast systems, involving additional channels or a different geography or both and 32 transmitters per site with as many as 222 system transmitters. The decision for Mesa is not whether quasi-synchronous system works, but whether moving part of its radio communications to an 800MHz trunking system will obviate the need to simulcast more of its existing system.

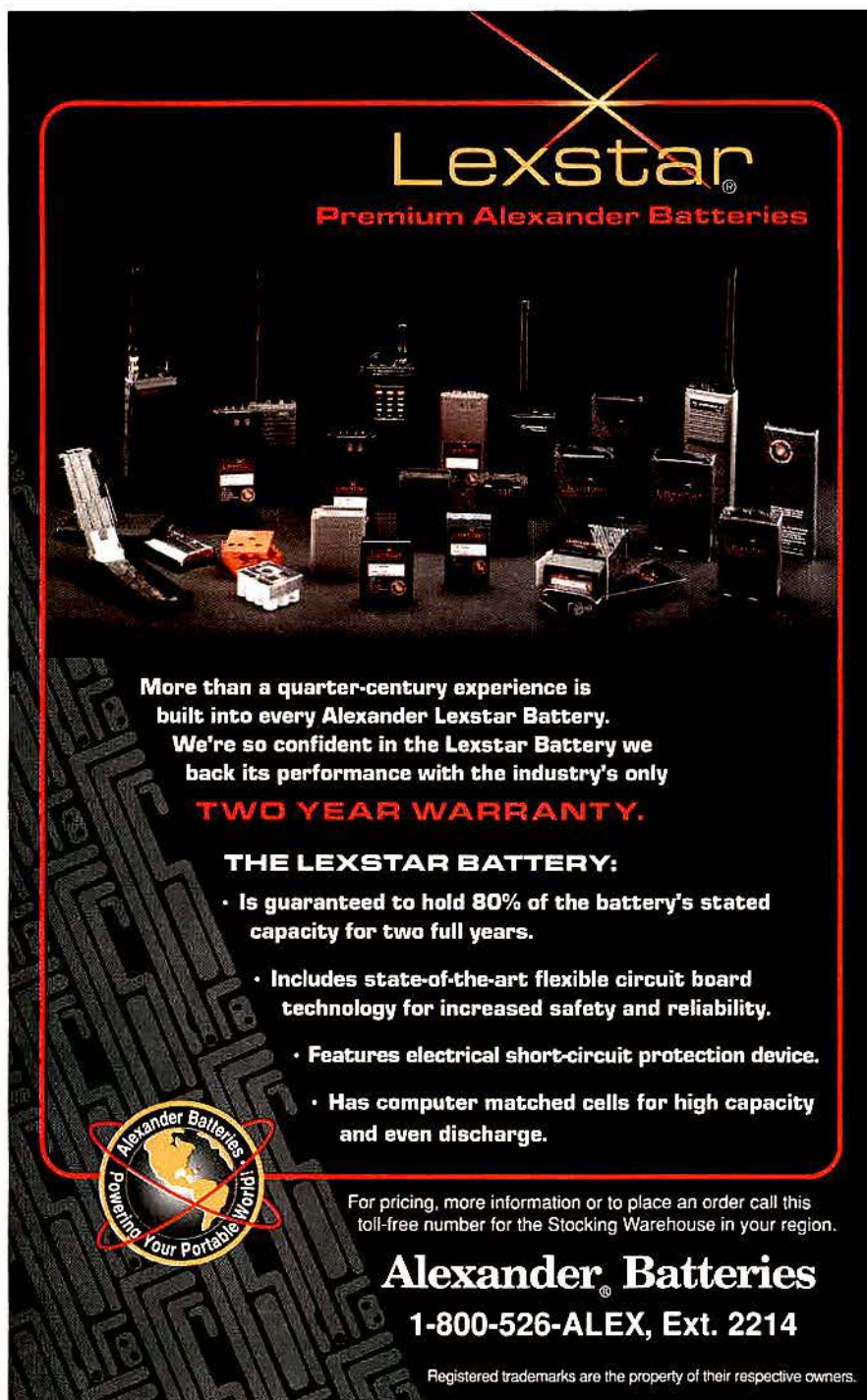
#### Conclusion

Quasi-synchronous simulcast system technology has been demonstrated in a real-world public safety environment that established the following milestones:

- The system works with other manufacturers' infrastructures. It was designed for retrofitting as well as for new systems.
- The system has proved that a simulcast system using CTCSS is both feasible and cost-effective.
- The system is frequency-independent.
- The system eliminates most of the continuing maintenance costs associated with tuning a simulcast system and keeping it functioning within acceptable performance limits.
- The system can be expanded within the existing software and computer system.

#### Acknowledgement

The author would like to acknowledge the effort of Mesa's project team members, including Dick Wiley and Mike Dieffenbaugh, and Tait's project team members, Neil Keller and Tony Bergeron. The city's employees used their experience from the previous simulcast project to help to set up and evaluate the beta test. The manufacturer's employees brought information about the quasi-synchronous simulcast system and learned about using it with a digital microwave system and CTCSS.



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# Improving the reliability of rechargeable batteries

*Some simple and effective methods can be used to prolong battery life, improve reliability and streamline record-keeping. If one or two 'exercise' cycles fail to reverse 'memory,' a 'recondition' cycle may be required.*

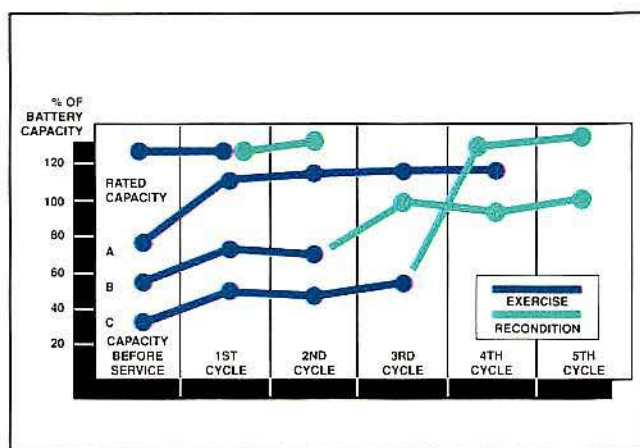


Figure 1. A new battery and three other batteries afflicted with various degrees of memory were analyzed. The batteries first were fully charged, followed by a discharge to 1V per cell. The resulting capacities were plotted on a scale of 0% to 120% in the first column. Additional discharge-charge cycles were applied, and the battery capacities were plotted in the subsequent columns. The blue line represents exercise; the green line represents recondition. Exercise and recondition cycles were applied manually at the research technician's discretion. See the text for a further description of the results.



Photo 1. This analyzer can service NiCd, NiMH and SLA batteries simultaneously. Different batteries interface through plug-in cups or cables that can be reprogrammed with the analyzer's menu function. With the printer option, battery service reports and labels can be generated.

By Isidor Buchmann

The performance and reliability of battery-powered devices are steadily improving, but the battery remains the weakest link. Unexpected downtime, excessive replacement costs and frustration are often the results of poor battery performance. Some simple and effective methods can be used to prolong battery life, improve reliability and streamline record-keeping.

The most commonly used commercial batteries are the nickel-cadmium (NiCd), nickel-metal hydride (NiMH) and sealed lead-acid (SLA). Much emphasis is placed

on the lithium-ion (Li-Ion) battery, and for good reasons—its energy density is twice that of the NiCd, and its charge retention is the best among rechargeable batteries. There is a price to pay, however. The Li-Ion is expensive. Calculating the cycle-cost based on service life and battery cost, the Li-Ion is five times as expensive as the NiCd. In comparison, the NiMH is four times, and the SLA is two-and-a-half times, as costly as the NiCd. For this study, the NiCd was based at \$0.04 per cycle.

For applications such as portable radios, cellular phones, video cameras, laptop computers and power tools, the most commonly used battery still is the NiCd. The reasons for its popularity are ease of recharge, excellent load current, economical price and long cycle life. In addition, the NiCd is forgiving if abused.

The NiCd has unique needs, however,

that must be met to get the long cycle life. Some users, especially those using portable radios, complain that their batteries do not last much longer than one year. On a daily discharge-charge regime, a one-year service life only results in 365 cycles. A reasonable life expectancy of the commercial NiCd battery is two to four years or 700 to 1,500 discharge-charge cycles.

In many ways, the NiCd battery exhibits human-like characteristics: It requires good nutrition and needs regular exercise. The importance of exercise is illustrated in the following study:

A Canadian park board had to replace all of its NiCd batteries after a short 15 months of service life. Lack of regular exercise was suspected. After acquiring a new set of batteries, the board agreed to implement a monthly exercise scheme.

Because of some delays, the first

Buchmann is the founder and chief executive officer of Cadex Electronics, Burnaby, British Columbia, Canada.





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exercise was done after four months. A careful analysis was taken to evaluate the condition of each battery at that stage. The results were startling—half of the batteries analyzed already exhibited a memory-related capacity loss of 25% to 35%. Because these batteries were used under light duty and never had to do a full day's work, they acquired the chemical equivalent of the human attitude "Why should I work hard if I don't have to?" With exercise—and some

needed recondition cycles—all of the batteries were restored to 100% capacity.

Some battery applications, including those for hand-held radios, fall into the pattern of partial discharge followed by a routine recharge. This lack of exercise causes the NiCd cell to revert to a lower oxide state, resulting in what is commonly known as "memory."

The word "memory" is derived from "cyclic memory," meaning that a NiCd

battery can remember how much energy was required on the previous application. Improvements in battery design have virtually eliminated this phenomenon; therefore, the capacity loss of the NiCd is not the result of cyclic memory, but of "crystalline formation." (Hereafter, when we refer to memory we are referring to crystalline formation.)

Memory can be reversed by applying one or two discharge-charge cycles to 1V per cell. This procedure is known as "exercise." In advanced cases, exercise is not sufficient to restore a battery, and "recondition" is required. Recondition is a secondary discharge at a much reduced current that drains the cell of its remaining energy.

In the following study, four batteries afflicted with various degrees of memory

*The word "memory" is derived from "cyclic memory," meaning that a NiCd battery can remember how much energy was required on the previous application.*

are analyzed. The batteries were first fully charged, followed by a discharge to 1V per cell. The resulting capacities were plotted on a scale of 0% to 120% in the first column of Figure 1 on page 48. Additional discharge-charge cycles were applied, and the battery capacities were plotted in the subsequent columns. The blue line represents exercise; the green line represents recondition. Exercise and recondition cycles were applied manually at the research technician's discretion.

Battery A responded well to exercise alone. This result is typical of a battery that has been in service for only a few months or that has been exercised periodically. Batteries B and C required recondition (green line) to recover full performance. The capacity of the new battery was further enhanced after recondition was applied. When examined after six months of field use, the batteries still showed excellent capacity readings.

Technology is now available to analyze and recondition rechargeable batteries automatically. Advanced battery analyzers identify and reverse the degeneration process by applying the appropriate service to restore the battery.



Receive only	Freq. Ranges (MHz)	N.F. (dB)	Gain (dB)	Comp. (dBm)	Device Type	Price
P30VD, P35VD, P40VD, P45VD	30-35, 35-40, 40-45, 45-50	<1.3	15	0	DGFET	\$ 44.95
P30VDG, P35VDG, P40VDG, P45VDG	30-35, 35-40, 40-45, 45-50	<0.5	26	+12	GaAsFET	\$109.95
P150VD, P160VD, P170VD	150-160, 160-170, 170-180	<1.5	15	0	DGFET	\$ 44.95
P150VDA, P160VDA, P170VDA	150-160, 160-170, 170-180	<1.1	15	0	DGFET	\$ 56.95
P150VDG, P160VDG, P170VDG	150-160, 160-170, 170-180	<0.5	24	+12	GaAsFET	\$109.95
P450VD, P460VD	450-460, 460-470	<1.8	15	-20	Bipolar	\$ 49.95
P450VDA, P460VDA	450-460, 460-470	<1.2	16	-20	Bipolar	\$ 74.95
P450VDG, P460VDG	450-460, 460-470	<0.5	16	+12	GaAsFET	\$109.95
P800VDG, P830VDG, P860VDG	800-830, 830-860, 860-890	<0.6	19	+12	GaAsFET	\$119.95
<b>Inline (rf switched)</b>						
SP30VD, SP35VD, SP40VD, SP45VD	30-35, 35-40, 40-45, 45-50	<1.4	15	0	DGFET	\$ 74.95
SP30VDG, SP35VDG, SP40VDG, SP45VDG	30-35, 35-40, 40-45, 45-50	<0.55	26	+12	GaAsFET	\$139.95
SP150VD, SP160VD, SP170VD	150-160, 160-170, 170-180	<1.6	15	0	DGFET	\$ 74.95
SP150VDA, SP160VDA, SP170VDA	150-160, 160-170, 170-180	<1.2	15	0	DGFET	\$ 86.95
SP150VDG, SP160VDG, SP170VDG	150-160, 160-170, 170-180	<0.55	24	+12	GaAsFET	\$139.95
SP450VD, SP460VD	450-460, 460-470	<1.9	15	-20	Bipolar	\$ 79.95
SP450VDA, SP460VDA	450-460, 460-470	<1.3	16	-20	Bipolar	\$104.95
SP450VDG, SP460VDG	450-460, 460-470	<0.55	16	+12	GaAsFET	\$139.95

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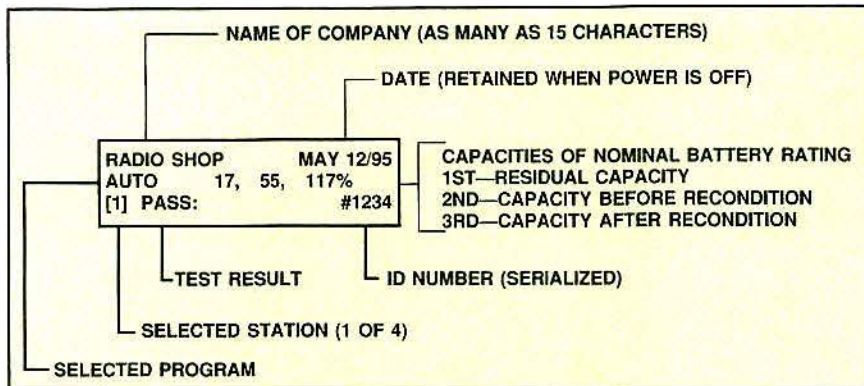


Figure 2. The battery label keeps track of the battery in the same way a service sticker on a car reminds the owner of pending service.

The analyzer shown in Photo 1 on page 48 can service NiCd, NiMH and SLA batteries simultaneously. Different batteries interface through plug-in cups or cables that can be reprogrammed with the analyzer's menu function. With the printer option, battery service reports and labels can be generated.

#### Selecting the right battery analyzer

During the last few years, the need for battery analyzers has increased rap-

idly. The demand is keeping pace with commodities such as cellular phones and laptop computers. Battery analyzers have proven to be effective in improving battery reliability and cutting cost. Although some analyzers are more effective than others, the buyer has a good selection of units in different sizes and price classes. When shopping for a new battery analyzer, consider the following attributes:

(1) An analyzer should be able to serv-

ice a large variety of battery types, including NiCd, NiMH and SLA.

(2) Programmable units that service the battery at the actual voltage and current are the fastest and provide the most accurate readings because the battery is analyzed under true field conditions.

(3) Analyzers with interchangeable battery adapters will not become obsolete when new batteries are introduced. The buyer should make sure that new batteries will indeed be supported in the future. Battery adapters that automatically set the analyzer to the correct battery characteristics when installed are the easiest to use, and they eliminate operator error.

(4) Analyzers that display the test results in percentage rather than milliamper-hour (mAh) units simplify operation because the user does not need to know the mAh ratings of each battery analyzed. With percentage readout, an additional level of automation can be implemented by applying a different service if the battery cannot reach a preset capacity. A higher level of automation eliminates trial runs, reduces handling, saves time and allows for use by operators with less training.

(5) Analyzers that feature the recondition cycle are more effective than those that only cycle the battery. NiCd batteries with advanced memory often do not recover by repeated discharge cycles to 1V per cell alone.

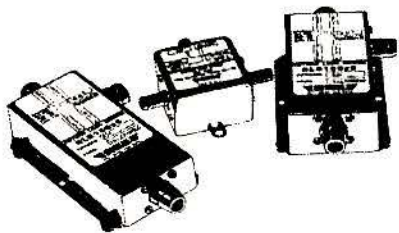
(6) An analyzer that displays the residual as well as the final battery capacities helps to verify that sufficient energy reserve is available at the end of a work shift. Adjustments in terms of battery size and duration of service can be made effectively and without guesswork.

(7) An analyzer should be capable of identifying a battery with a shorted cell. Such a defect may go unnoticed if serviced with an analyzer that does not check for the correct battery voltage.

(8) The buyer should be aware of throughput and service time, especially when larger batteries are analyzed. NiCd batteries with ratings as high as 2,000mAh should be charged in less than two hours; the discharge time should take one hour for 100% capacity. Faulty batteries should be identified quickly to free the station for other batteries.

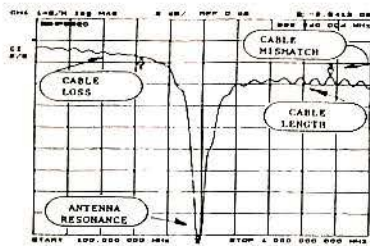
(9) An analyzer should be capable of producing print reports. Battery labels are particularly handy because the test results and date of last service can be contained on a small label and attached to the battery. (See Figure 2 above.)

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Return loss bridges from Eagle cover from .04 MHz to 3.0 GHz. These are self contained units that require no attenuators, amplifiers or detectors. All the additional equipment is contained in your service monitor or spectrum analyzer. Five watt power rating, unmatched in the industry, protects YOUR bridge from power coming from the antenna at crowded sites. Rugged nickel plated brass enclosures assure excellent durability and shielding.

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# Build a crystal filter to solve VHF interference

*When adjacent-channel signals as close as 15kHz to the desired frequency interfere with reception, a crystal filter may offer the best solution to combine low insertion loss with high attenuation.*

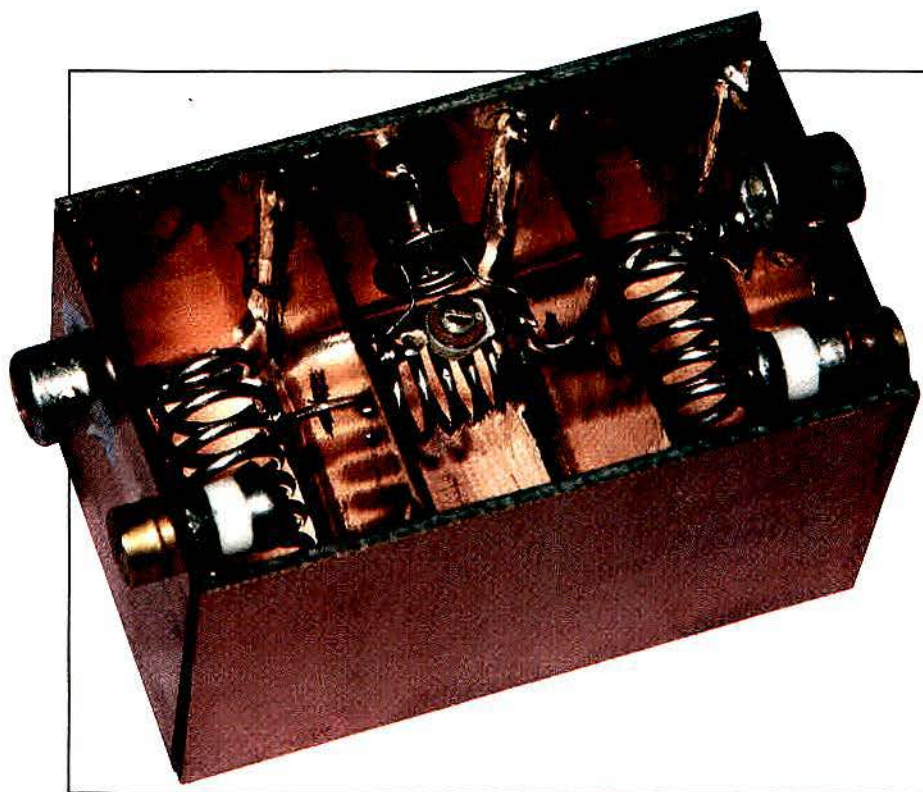
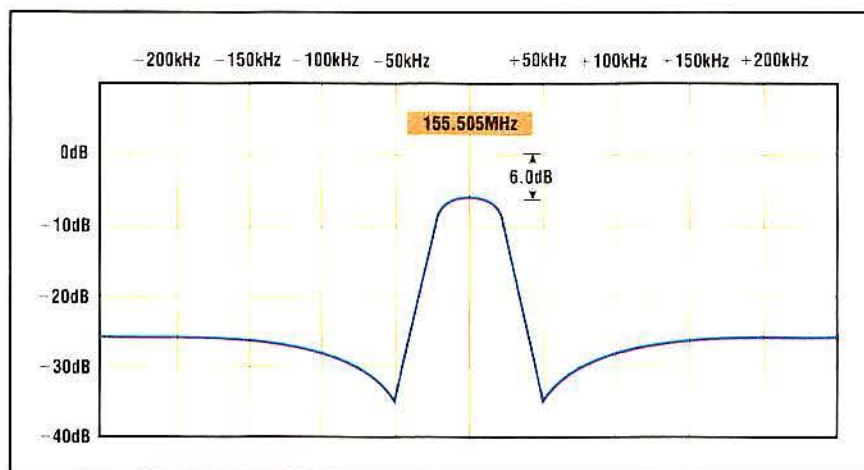


Photo 1. The single-filter, high-pass and low-pass filter of Figure 2 on page 56.



By Patrick E. Buller

One of the best solutions for adjacent-channel VHF highband interference is a crystal filter.

But where do you find one? There are very few crystal filter vendors listed in catalogs and product directories.

A homemade crystal filter can reduce by 25dB a VHF highband only 15kHz from the desired signal with only 1.0dB of insertion loss.

With more and more VHF stations appearing as if from nowhere, adjacent-channel interference has become a problem with no ready or reasonable solution. Large (10-inch) cavities configured as notch filters are inefficient for resolving interference caused by signals less than 100kHz from the desired channel frequency. A device with much higher "Q" is necessary for spacings closer than 100kHz.

## High "Q" solution

Crystals, with "Q" values higher than 70K, are the solution. A crystal filter can be configured either as a high-pass or low-pass notch filter with low insertion loss and, with a second crystal, as a symmetrical band-pass filter.

For many years, Motorola has offered

Figure 1. The Motorola model TLD6340A crystal selectivity curve with an 18.0kHz passband, 6.0dB insertion loss and 40dB maximum attenuation at a spacing of about 120kHz from the center frequency. Attenuation specifications are 13dB, adjacent channel, and 20dB minimum for alternate channels and greater.

Buller is an electronics design engineer for the Washington State Patrol, Bellevue, WA. He is a member of the Radio Club of America, IEEE, NARTE and APCO. He earned an amateur radio license in 1950, a commercial radio license in 1959 and a B.S.E.E. in 1963.





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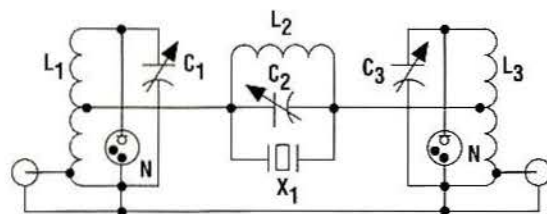


Figure 2A. This schematic diagram represents the best single-crystal, high-pass and low-pass filter based on the Washington State Patrol filter experiments. It uses an AT cut, 5th overtone crystal on 150MHz-160MHz frequencies.

#### SINGLE-CRYSTAL HIGH-PASS/LOW-PASS NOTCH FILTER

- $L_1, L_3$  7 turns No. 16 AWG, 5/16" I.D., spaced 7/8", tapped at 3/4 turn input
- Output tapped at 3/4 turns from cold end for crystal
- $L_2$  6 turns No. 18 AWG, 5/16" I.D., spaced 5/16"
- $C_1, C_3$  10pF variable capacitor, Voltronics AP10SD
- $C_2$  8pF ceramic trim capacitor
- N NE-2 neon bulb

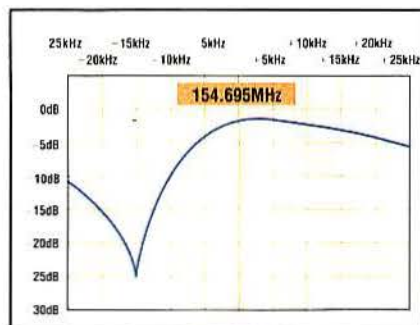


Figure 2B. The response curve of the filter adjusted for high-pass applications.

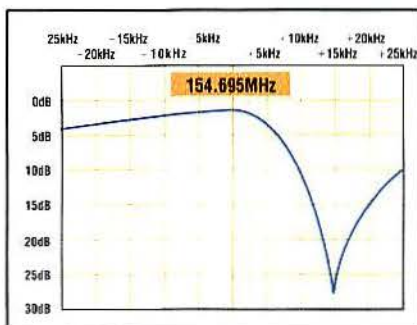


Figure 2C. The response curve of the filter adjusted for low-pass applications.

VHF crystal filters with a passband of 18.0kHz, 6.0dB of insertion loss and 40dB maximum attenuation at a spacing of about 120kHz from the center frequency. Attenuation specifications are 13dB, adjacent channel, and 20dB minimum for alternate channels and greater. Figure 1 on page 54 gives the 1972 specifications.

Crystals in the Motorola device can operate directly across a parallel-tuned circuit; nevertheless, attenuation is about 10dB. This filter has little value as protection from today's adjacent channel interference.

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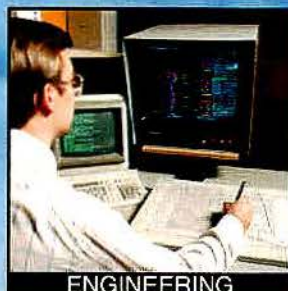
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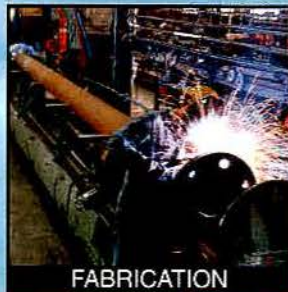
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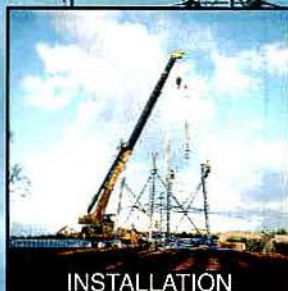
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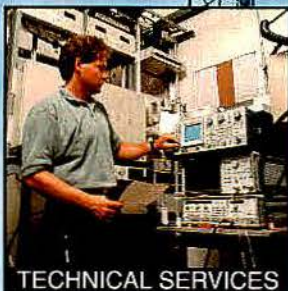
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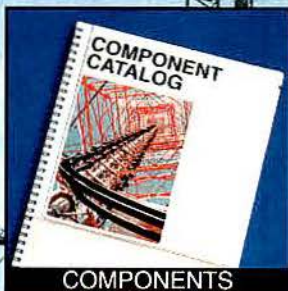
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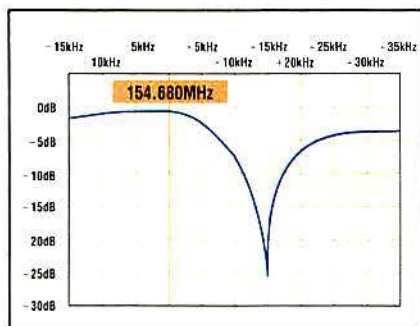
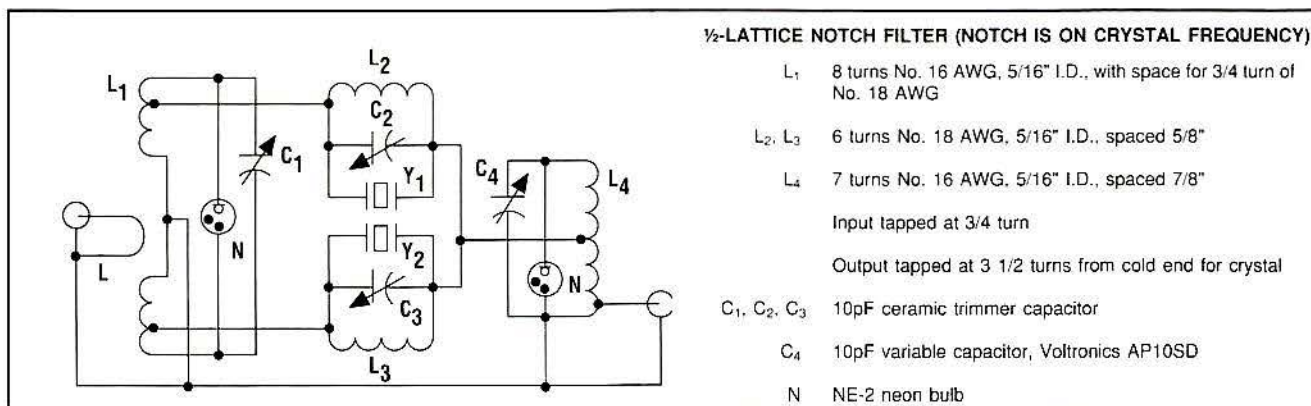


Figure 3B. The response curve adjusted for the high-attenuation, low-pass band-reject mode.

Figure 3A. The schematic diagram represents a half-lattice filter where the notch frequency is that of the two crystals. For greater bandwidth at the notch, one crystal should differ from the other by the required separation, perhaps 5kHz. The distinct advantage of this method is the quantity of notch attenuation obtainable—nearly 65dB with 2.0dB insertion loss, as shown in Figure 3B. Parallel resonant circuits L2 and L3 shift the crystal's resonant properties for the greatest attenuation.

Piezo Crystal, a vendor that was interested in cooperating in the Washington State Patrol filter experiments, can supply AT cut, 5th overtone crystals on 150MHz–160MHz frequencies. Many circuits were tried during the research and development stage that resulted in a more thorough understanding of crystal behavior in this ap-

plication. The best single-crystal, high-pass and low-pass filter is shown in Photo 1 on page 54 and Figure 2 on page 56. High-pass and low-pass characteristics are shown in Figures 2B and 2C.

#### Simplified design

The advantage of this design is that the

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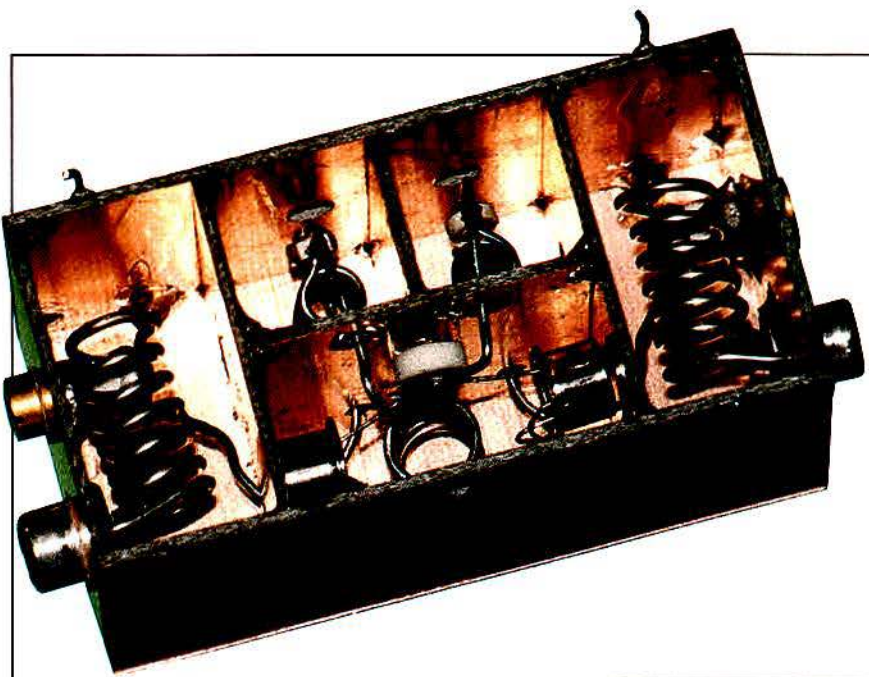


Photo 2. This picture shows the band-pass filter of Figure 4.

crystal determines the pass frequency, and its shunt element determines the notch frequency. This design resembles tunable cavities used for duplexing and combining

where cavity tuning determines the pass frequency, and link tuning sets the reject frequency. This approach to crystal filter tuning simplifies the design. Choose the

crystal for your pass channel frequency and tune to the interference.

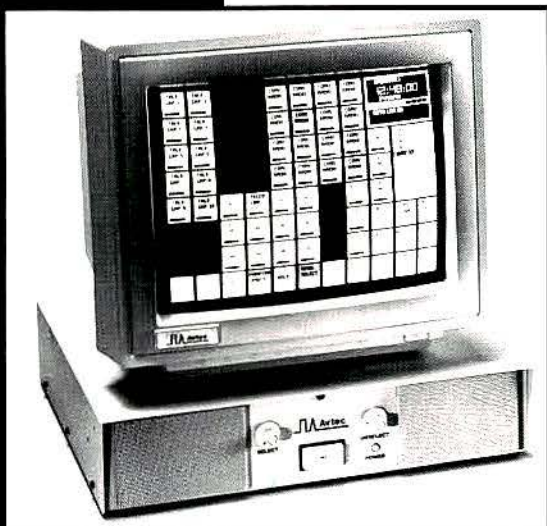
Input and output coils, L1 and L3 in Figure 2, match the 50V input and output line impedance to the Piezo crystal impedance, minimize the insertion loss and provide a small phase shift to compensate for slight crystal differences.

Tuning L2 from high-pass to low-pass, or the reverse, without tuning L1 and L3 does not yield low insertion loss. Changing the "tank Q" to fewer turns and increasing the capacity results in less flexibility in adjusting from high-pass to low-pass applications. All 20 crystals used for research and development matched the same impedance tap on the tuned coils.

#### Half-lattice filter

Figure 3 on page 58 is the schematic of a half-lattice filter, where the notch frequency is that of the two crystals. For greater bandwidth at the notch, one crystal should differ from the other by the required separation, perhaps 5kHz. The distinct advantage of this method is the quantity of notch attenuation obtainable—nearly 65dB with 2.0dB insertion loss, as shown in Figure 3A. Parallel resonant circuits L2 and L3 shift the crystal's resonant properties

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Figure 4A. The schematic diagram of a band-pass crystal filter with two crystals on the same frequency. Each crystal shunt element is tuned to the first adjacent channel above and the first adjacent channel below. The advantage of this circuit is that it can be tuned as a band-pass filter (Figure 4B) or as a band-reject filter (Figure 4C) with higher attenuation than what can be obtained with the single-crystal method.

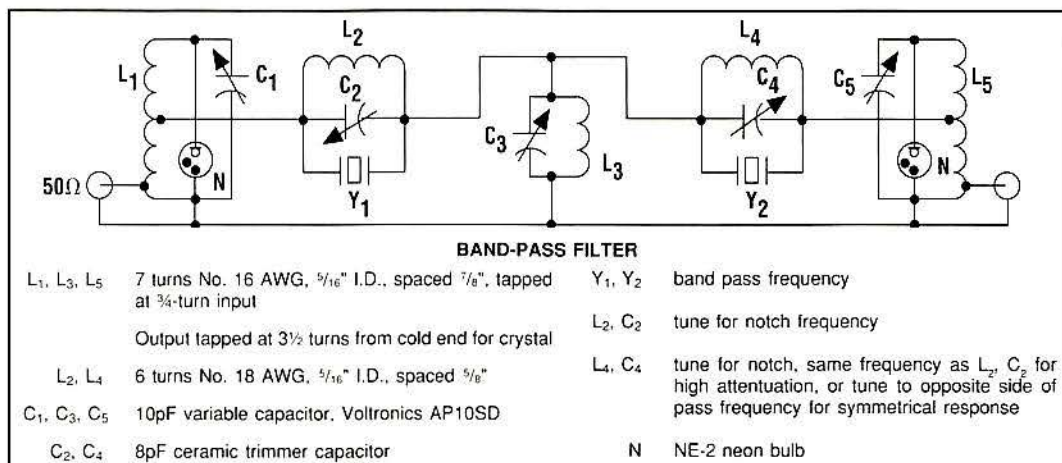


Figure 4B. Response curve of the two-crystal filter adjusted for band-pass applications.

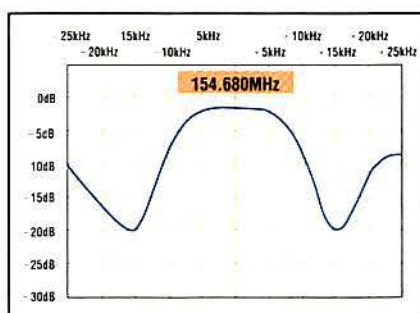
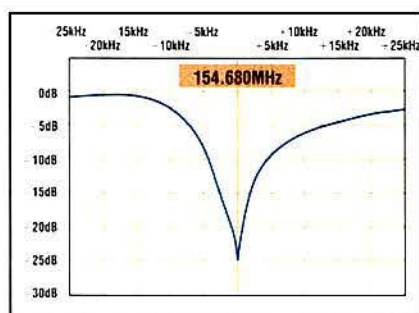


Figure 4C. Response curve of the two-crystal filter adjusted for a single-frequency notch.



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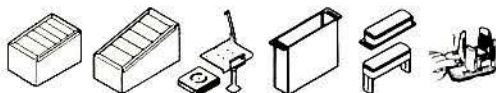
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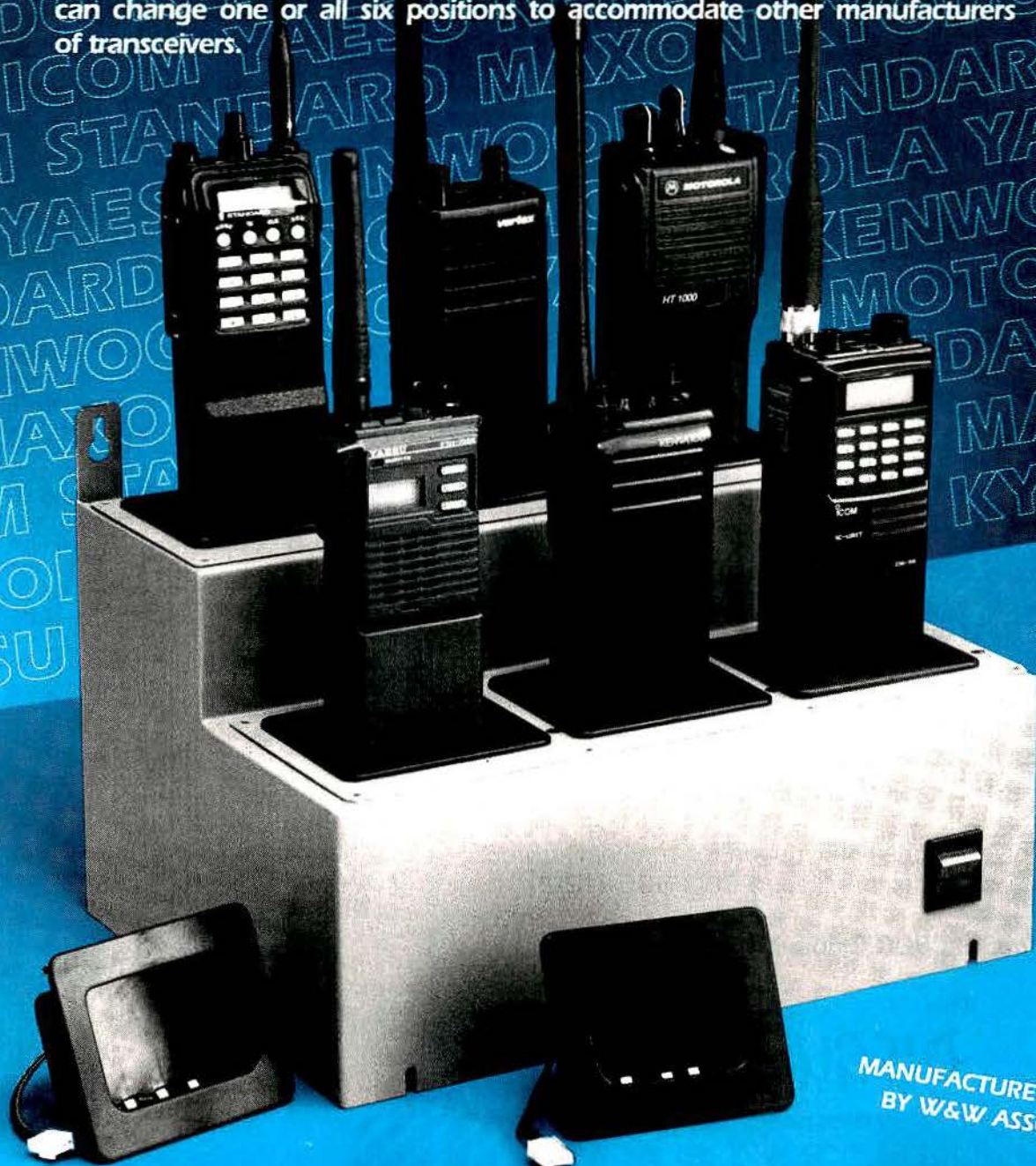
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for the greatest attenuation.

Photo 2 on page 60 and Figure 4 on page 62 represent a band-pass crystal filter with two crystals on the same frequency. Each crystal shunt element is tuned to the first adjacent channel above and the first adjacent channel below. The advantage of this circuit is that it can be tuned as a band-pass (Figure 4B) or as a band-reject filter with higher attenuation than the single-crystal method.

Interaction in tuned circuits L2 and L4 prevents uniform attenuation curves in the reject mode. (See Figure 4C.) Its attenuation is better than two filters in series (as shown in Figure 2) by about 0.75dB.

#### Filter characteristics

With a spectrum analyzer and a tracking generator, it is possible to display the filter's characteristics. Notice in Figure 4A that there are "spurs" (spurious responses)

above the crystal frequency at a lower level. These spurs have no effect upon the receiver's "on-frequency" performance.

Field tests with a 25dB notch filter, like the one in Figure 2, reduced a 15kHz adjacent signal from 300mV to 15mV, including the filter's 0.8dB insertion loss. The tests also proved that it interfaced in series with 10-inch cavities without additional loss.

The design of the Figure 2 filter was optimized for close-channel problems, although it can be tuned from the crystal frequency to approximately 100kHz on the low-frequency side and nearly 65kHz on the high-frequency side. For interference control at frequencies beyond 150kHz from the center frequency, there are other, more efficient, circuit arrangements.

#### Making adjustments

A spectrum analyzer with a tracking generator (or with signal generator and a tracking source) makes adjustments simple. If you are without these instruments, try this approach: Align input and output coils L1 and L2 of the filter, as in Figure 2, for maximum output signal at the received (crystal) frequency. Apply a signal at the desired notch frequency, and tune L3 for maximum attenuation at the output. Always have a valid 50V resistive load on each side of the filter for optimum performance.

Manufacturing 5th overtone crystals at this frequency is rather difficult. The first devices that were tried had little attenuation. At Piezo Crystal, it was theorized that the leads attached directly to the crystal element were too large, restricting performance.

The second-generation devices proved the theory. The 7th overtone has less notch attenuation than the 5th and 3rd overtones.

The enclosure for the crystal filters is made from double-sided printed circuit board stock soldered within each compartment. RCA phono jacks are used for in/out connections. Coils for the single-crystal filter shown in Figure 2 were wound on a common round pencil with a  $\frac{3}{16}$ -inch diameter.

These filter ideas can be further developed to suit other needs. Someone probably will substitute toroids for the inductors, or perhaps slug-tuned coils. Use what you have.



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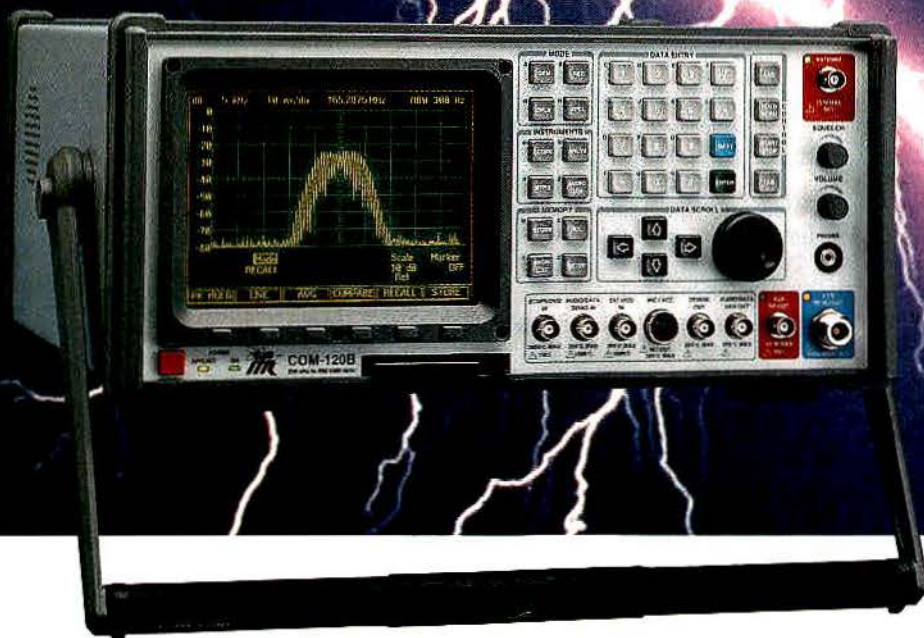
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# Coaxial connectors: 7/16 DIN and type N

*Part 2—Along with the electrical differences described in part 1, the 7/16 DIN connector's power-handling capacity and mechanical differences may indicate its use in place of the type N for some installations.*

By Jeffrey D. Paynter  
and Richard Smith

The 7/16 DIN connector<sup>1</sup> often is used with high-power RF transmission lines. Radio manufacturers are using 7/16 DIN in applications such as cellular base station transmitters, at the output of ampli-

ers and on combiners. On the other hand, type N interfaces often are used for receiving channels where average powers are lower. The 7/16 DIN also is being used for the input interface on the antennas used in high-power two-way radio applications such as paging and digital specialized mobile radio (SMR).

Historically, in the United States, LC connectors have been used when higher power was required, but the LC interface was not developed with intermodulation as a design factor and thus is not adequate for intermodulation-sensitive applications.

Peak power is the maximum power that can be used without the danger of energy arcing between conductors. The peak power rating is a function of the smallest air gap between inner and outer. A larger

"DIN" stands for Deutsche Industrie Normen (German Industrial Standard). DIN 47 223 specifies a high-frequency coaxial connector with a characteristic impedance of 50Ω. "7/16" represents a nominal value of 16mm at the interface for the internal diameter of the external conductor, and a nominal value of 7mm for the external diameter of the internal conductor to achieve 50Ω.

Paynter is senior design engineer, and Smith is manager, Connector Engineering, Andrew Corporation, Orland Park, IL.

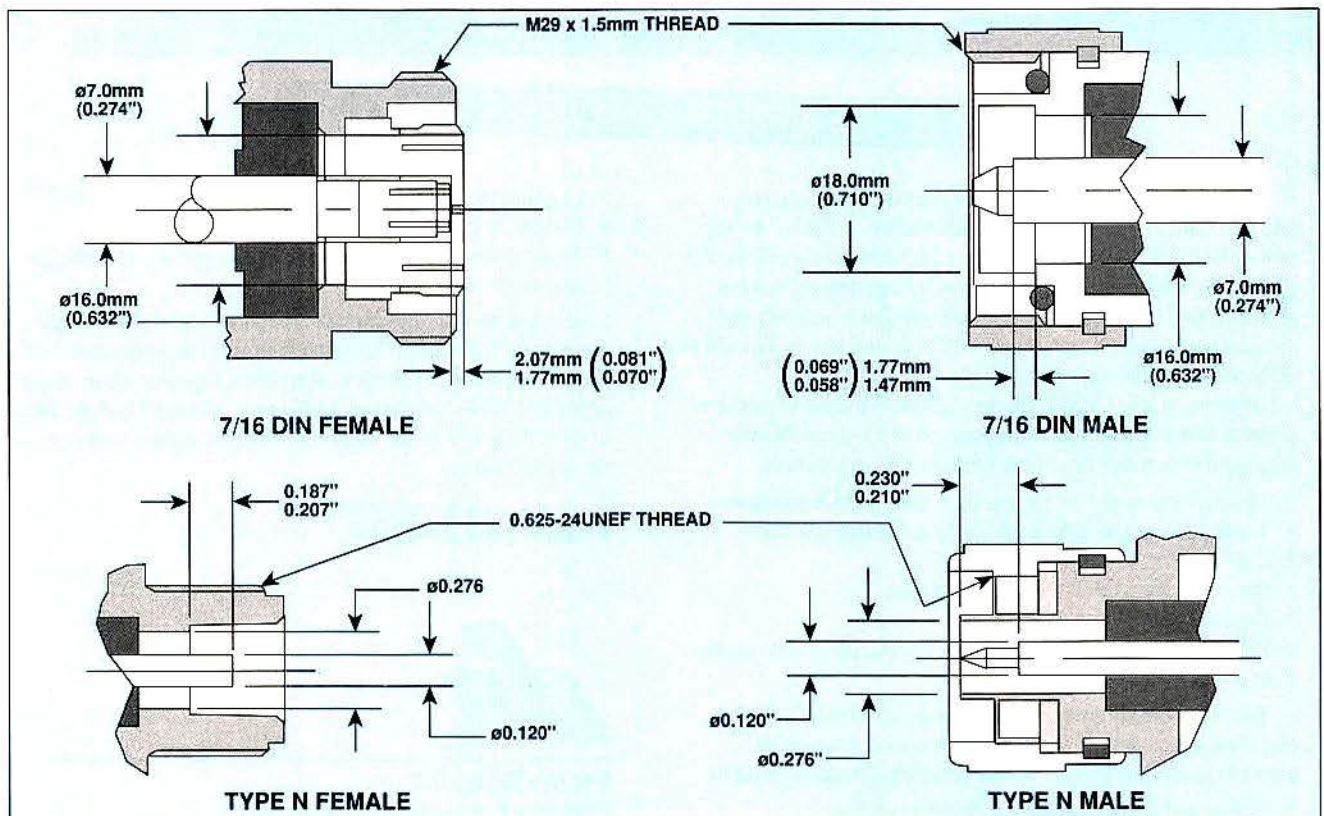


Figure 1. The 7/16 DIN and type N interface design details.



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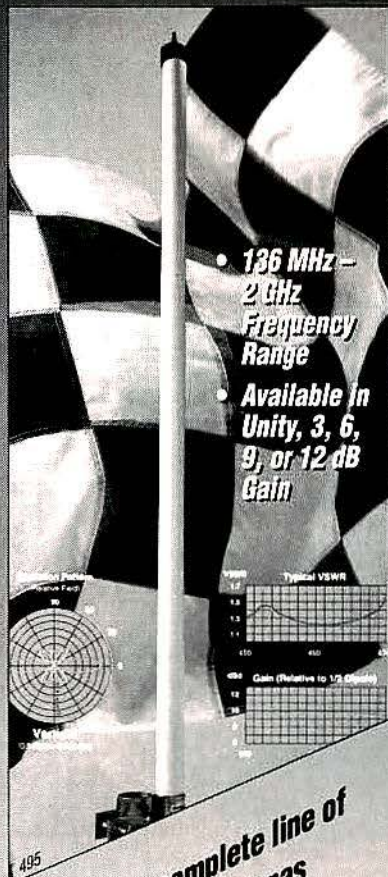






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air gap provides a higher peak power rating, hence, the 7/16 DIN interface, with its larger air gap, has a rating of 40kW compared to only 10kW for the type N.

Average power is difficult to specify absolutely because of the complexity of the thermal problem to be solved. There are a number of factors, such as ambient temperature, solar radiation, wind effects and variations in contact resistance that cannot be totally controlled by the design of the connector. A typical average power limit for the type N interface at 800MHz is 600W, compared to a limit for the 7/16 DIN interface of 3,000W.<sup>2</sup> This five-fold increase in average power handling for the 7/16 DIN interface results from higher contact pressure, lower contact resistance and better heat dissipation provided by larger conductor surfaces.

► *Compensation* — Another advantage of the 7/16 DIN is better VSWR performance. This performance is related to several factors. First, as mentioned previously, the pin depth tolerance is tighter, reducing a primary source of reflection from an interface. Second, because the bandwidth is narrower, the design can be optimized for the lower frequency range. Compromises at the lower frequencies often must be made to provide adequate performance over the wider bandwidth of type N connectors. Third, the larger physical dimensions once again provide an ad-

vantage, because proportionally, 7/16 DIN connectors are longer than type N connectors, allowing the transition from the cable to the interface to be more gradual. A VSWR of 1.04 at 1GHz and 1.10 at 2GHz is common for a 7/16 DIN connector. Table 1 below lists some characteristics of several connector styles.

### Mechanical performance

► *Dimensions* — The larger interface size of the 7/16 DIN compared to the type N is responsible for many of its mechanical and electrical performance advantages. It has an outer and inner contact diameter of 0.630" (16mm) and 0.275" (7mm), respectively, compared to 0.276" and 0.120" for the type N. (See Figure 1 on page 66.)

► *Contact pressure* — The 7/16 DIN joint ensures a more stable electrical and mechanical connection than the type N. It has less chance of loosening over time, longer service life, lower contact resistance and improved intermodulation performance. Its interface dimensions and coupling nut torque are about 10 times greater than those of the type N. This torque provides almost three times greater contact pressure at the outer body connection. Although the female inner contact

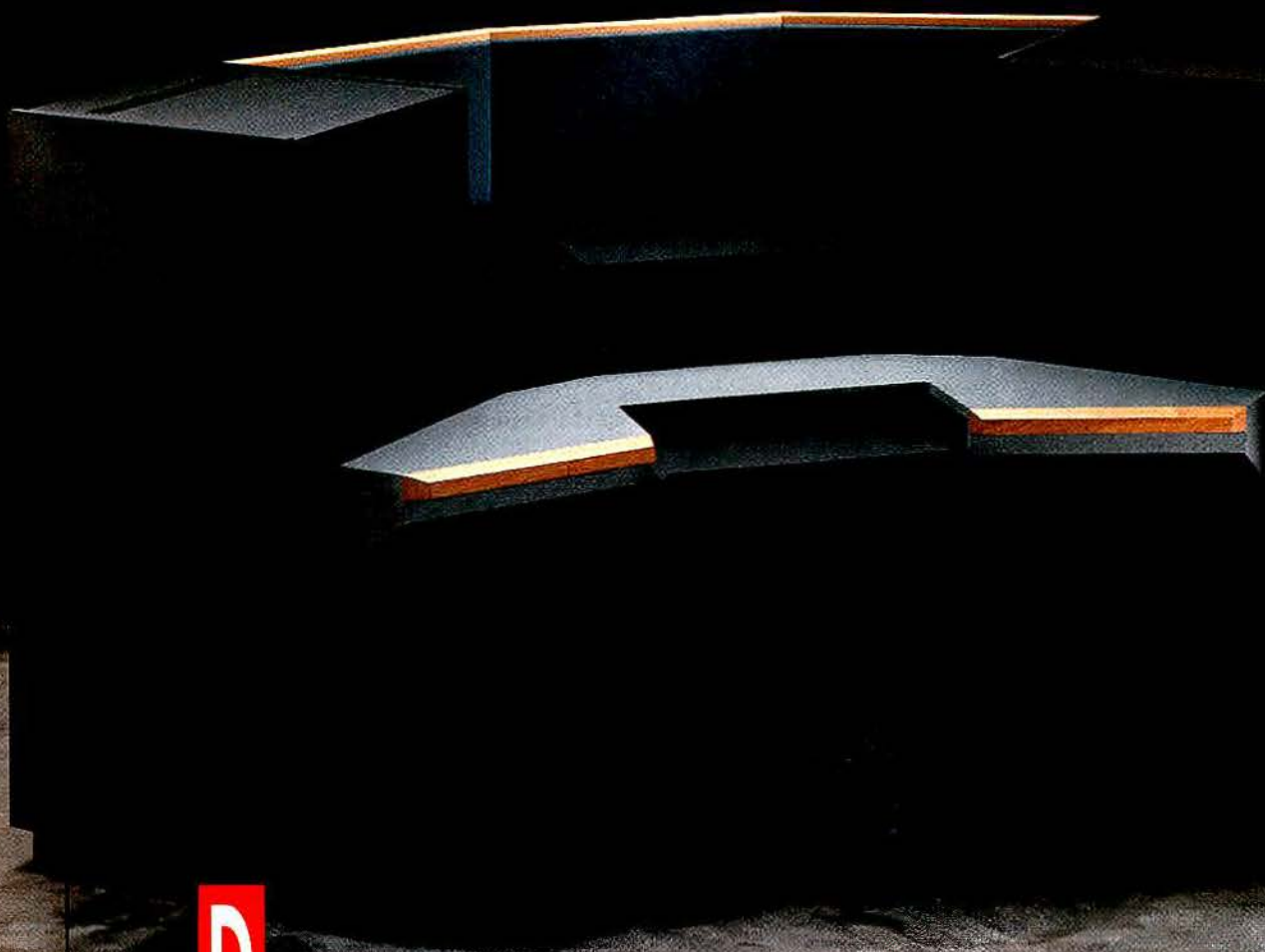
<sup>2</sup>These limits would require derating for variable standing wave ratio (VSWR), modulation and ambient temperature.

TABLE 1—Electrical and mechanical characteristics for several connector styles.

	TYPE N	7/16 IEC/DIN	4.1/9.5 IEC/DIN	7/8" EIA
MAX. FREQUENCY, GHz	12	6	9	5
AVERAGE POWER, kW (AT 800MHz)	0.6	3	1.2	CABLE LIMITED
PEAK POWER, kW	10	40	16	90
TYPICAL THIRD-ORDER IM, dBm (20W CARRIERS)	-125	-130	-125	-140
PIN DEPTH RANGE, INCHES	MALE 0.230-0.210 FEMALE 0.207-0.187	0.069-0.058 0.081-0.070	0.211-0.199 0.198-0.186	N/A
COUPLING TORQUE, IN.-LBS.	15-20	220	88	N/A
OUTER COUPLING METHOD	HEX NUT	HEX NUT	HEX NUT	FLANGE
INNER COUPLING METHOD	PIN/SOCKET	PIN/SOCKET	PIN/SOCKET	BULLET
STANDARD OUTER PLATING	SILVER	SILVER	SILVER	SILVER
STANDARD INNER PLATING	GOLD	SILVER	SILVER	SILVER
CELLULAR APPLICATIONS	✓	✓	✓	✓
TERRESTRIAL MICROWAVE APPLICATIONS	✓		✓	
BROADCAST APPLICATIONS	✓	✓	✓	✓



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Photo 1. If properly designed and sealed at the cable connection, both type N and 7/16 DIN connectors can be used outdoors because they use interface gaskets. The 7/16 DIN male connector is less likely to loosen over time because of environmental stresses and vibration.

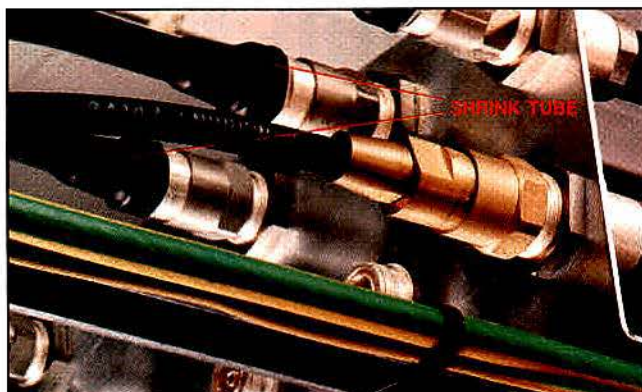


Photo 2. It is good practice to use weatherproofing systems such as butyl rubber tape or, as shown above, shrink tube.

geometry is not defined by either interface standard, the 7/16 DIN interface normally features a high contact pressure zone at the end of the inner contact pin that is not typical of the type N interface.

► **Pin depth requirement** — The tighter pin depth specification for the 7/16 DIN produces a more consistent VSWR performance and normally an improved VSWR compared to the Type N connector. The total tolerance range for the 7/16 DIN male

and female is 0.011"; for the type N male and female, the range is 0.020". As a result, with extreme tolerances, the interface gap between the mating pins can vary from 0.001" to 0.023" for the 7/16 DIN and 0.003" to 0.053" for the type N.

► **Environmental** — If properly designed and sealed at the cable connection, both types of connectors can be used outdoors because they use interface gaskets. At the interface, the 7/16 DIN connector

is almost double the size of the Type N. The interface gasket diameter difference is approximately 0.875" vs. 0.438". This difference, combined with the larger coupling nut on the 7/16 DIN male connector, makes it less likely that the connection will loosen over time because of environmental stresses and vibration. (See Photo 1 above left.) Regardless, for the hostile conditions that commonly occur on an antenna tower, it is good practice for

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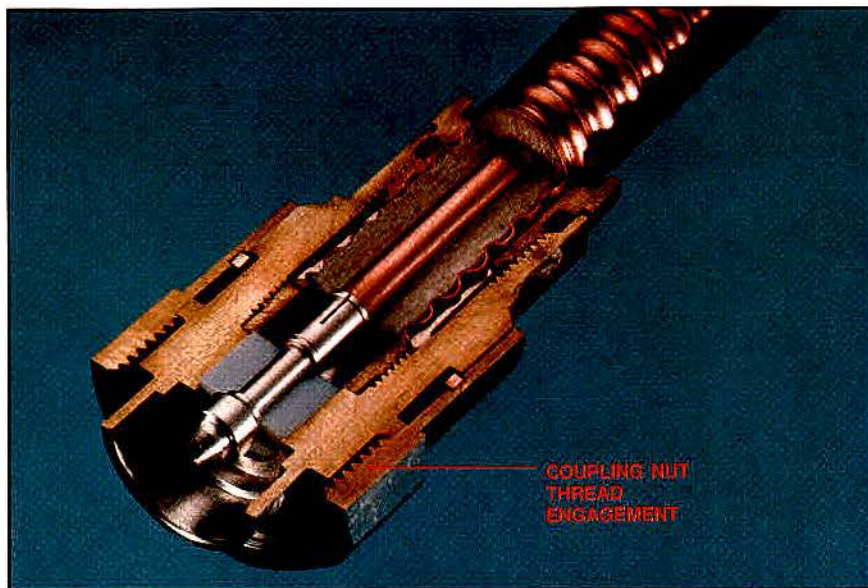


Photo 3. The 7/16 DIN connector's coupling nut has a large thread engagement, reducing the chance of cross-threading. A retractable coupling nut design, which is standard on most 7/16 DIN connectors, ensures positive conductor engagement, improving reliability.


either connector type to use weatherproofing systems such as butyl rubber tape or shrink tube. (See Photo 2 on page 70.)

► *Mating* — Assembly of the 7/16 DIN

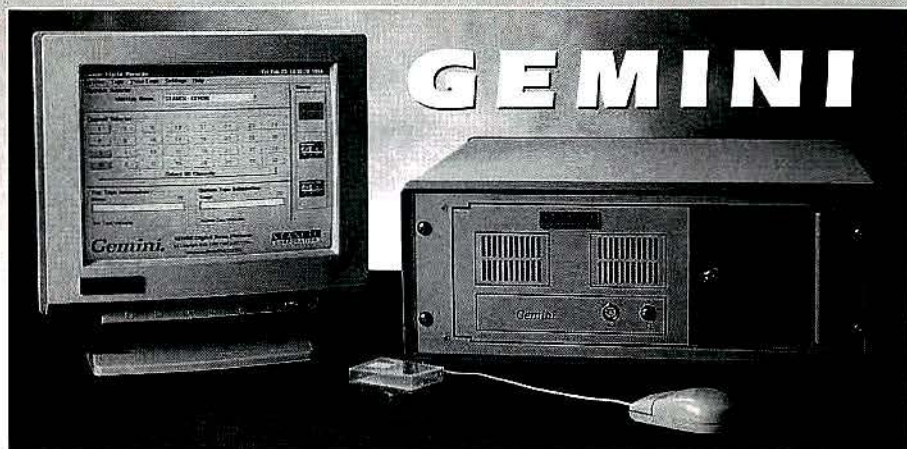
connector to the mating connector is easier with less chance of cross-threading because the larger coupling nut has a larger thread engagement. Furthermore, with the

addition of a retractable coupling nut design, which is standard on most 7/16 DIN connectors, positive conductor engagement can be ensured, improving reliability. (See Photo 3 to the left.)

#### Summary

With the performance improvements required for digital communication applications, use of the 7/16 DIN connector is becoming increasingly widespread. It enjoys many technical advantages over the type N interface. Intermodulation performance is more stable because of its higher contact pressure, greater coupling torque and robust design. Mating of the 7/16 DIN is easier and more reliable and, once mated, it has greater resistance to environmental forces. The 7/16 DIN can be used at higher power levels without degrading connector performance. By taking advantage of the narrower frequency range and tighter pin depth requirement, the VSWR performance of the 7/16 DIN can be optimized for cellular and mobile radio applications. The 7/16 DIN connector gives system engineers a technically superior, high-performance alternative to use when designing today's more challenging and demanding wireless systems. 

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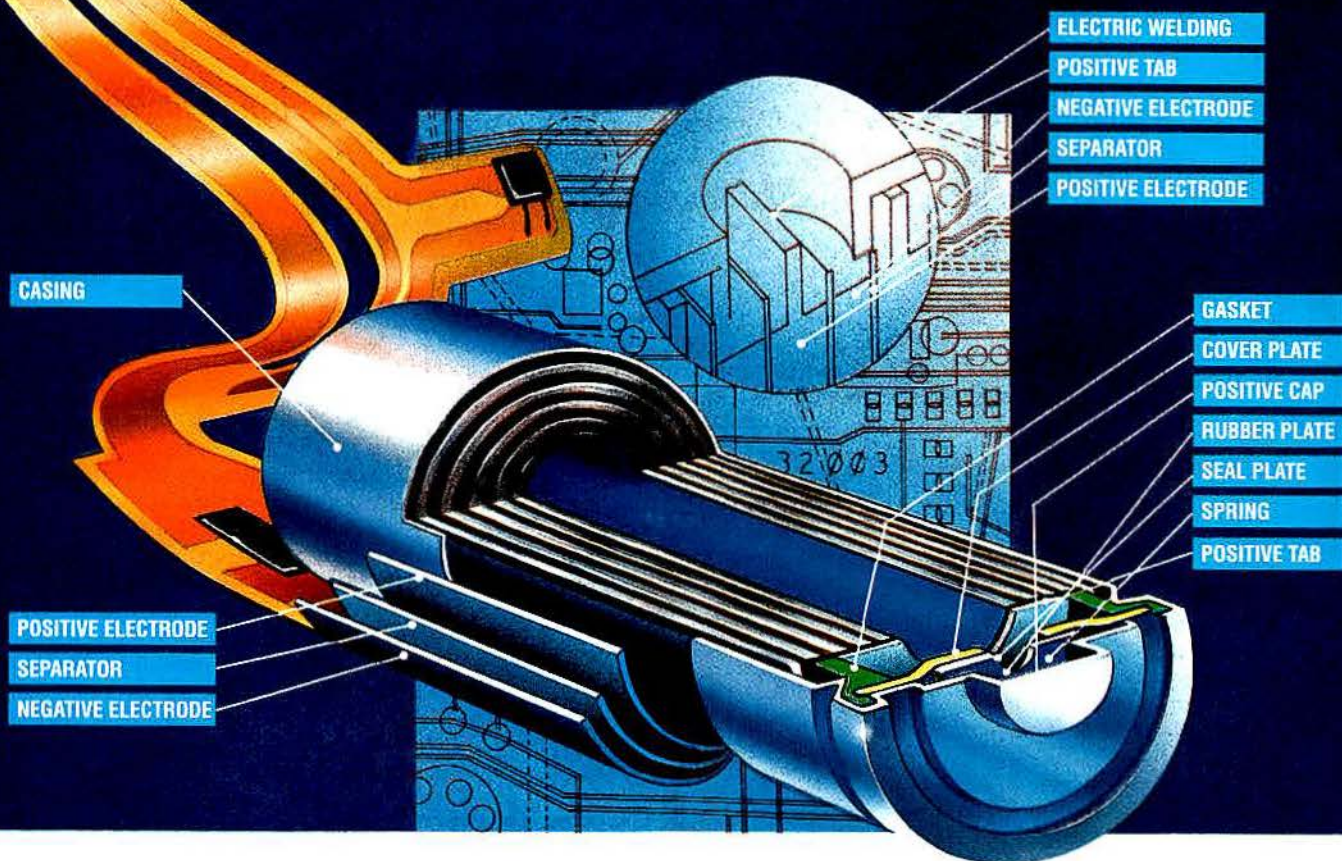
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# Selecting and servicing two-way radio microphones

*Selecting the right microphone depends on the environment in which the microphone is to be used, as well as the type of radio to be used. Tips are included for troubleshooting various microphone types.*

By Roald Steen

The microphone is an important part of a mobile radio system. Its purpose is to transform the acoustic energy of sound waves into a corresponding alternating electric current.

Several factors affect the way a microphone responds to acoustic energy. Among these are its frequency response and directivity. Microphones also have a characteristic electrical impedance that must match the impedance of the radio's microphone input circuit.

► **Frequency response**—The frequency response of most communications microphones is about 200Hz to about 3,000Hz or 4,000Hz. Considering that the ear can hear sound from about 50Hz to about 10,000Hz to 15,000Hz (depending on a person's age and health), the frequency response of a mobile radio microphone is not particularly good in comparison to the ear.

Fortunately, the mobile microphone's frequency range is adequate to carry virtually all of the sound required to understand the spoken word. Besides, the frequency response of the mobile radio through which the sound must pass tends to be even narrower. Everything considered, the typical mobile microphone works fine with mobile radios, repeaters and telephone circuits that may connect parts of the system.

► **Directivity**—Although unidirectional mics offer a desirable performance, omnidirectional microphones are used and accepted in the two-way radio industry.

► **Impedance**—Microphones generally are classified as high-impedance or low-impedance.

Carbon microphones and dynamic microphones tend to come with low impedance. Condenser microphones and piezoelectric (ceramic) microphones tend to have a high impedance. The microphone impedance has to match the radio's microphone input impedance.

Some microphones have a built-in, active, transistorized circuit that may transform the microphone element impedance and amplify its output.

## Element types

Microphone technology tends to be conservative. Many microphones have changed little in appearance from the mi-

phones, and their frequency response is poor.

► **Dynamic**—The dynamic microphone is another type that is widely used in the mobile radio industry. Its impedance is low, and it is rugged. In a dynamic microphone, a coil is attached to the microphone diaphragm and suspended between the poles of a permanent magnet. As the diaphragm makes the coil move in and out of the magnetic field in response to sound waves, electric currents are induced in the coil. Dynamic microphones can be made to fit into a variety of different directivity designs with a good frequency response.

► **Magnetic**—The controlled magnetic microphone resembles the dynamic microphone, except that the voice coil is firmly mounted in the microphone housing. One end of a magnetically permeable material is attached to the diaphragm, and the other is suspended between the poles of a permanent magnet. The magnetically permeable material moves as sound waves strike the diaphragm, and the amount of magnetism conducted to the voice coil changes correspondingly. The result is that electrical currents are induced in the voice coil in the same way as in a dynamic microphone. This design makes the controlled magnetic microphone a rugged type with good frequency response and low impedance.

► **Condenser**—The condenser microphone can be designed to be small, and it has an excellent frequency response and low distortion. Its high impedance may have to be transformed to match the mobile radio microphone input impedance.

The condenser microphone works similarly to a variable capacitor. The diaphragm is attached to one plate of the capacitor. When sound waves make the plate attached to the diaphragm move in an electric field created by a bias voltage, an alternating current is induced in

## Most microphone problems are caused by mechanical stress.

crophones that were used by World War II aviators or tank crews.

► **Carbon**—The carbon microphone is perhaps the oldest microphone type currently in use. It uses a carbon powder inside the microphone element. The carbon powder changes resistance to current flowing through the microphone element in accordance with the sound waves that enter the carbon element.

Carbon microphones are inexpensive and rugged, and their output signal power is high. These microphones are therefore found in many telephones and in many mobile radio systems. The problem with carbon microphones is that the microphone elements are noisy, they tend to distort the audio more than other micro-

Steen is an electronics instructor and free-lance writer. He has worked as a two-way radio technician, and he lives in Woodbury, MN.





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accordance with the sound waves.

► **Electret**—An electret microphone is similar to a condenser microphone, except that it does not need the bias voltage.

► **Piezoelectric**—The piezoelectric microphone uses a diaphragm attached to piezoelectric material. When this material is stressed mechanically as sound waves move the diaphragm, an alternating current is induced. Piezoelectric microphones, which are sometimes called *ceramic* microphones,

have a high-impedance output. They are inexpensive and can be made compact, but mechanical vibration tends to induce noise.

#### Microphone configurations

There are a variety of microphone configurations on the market. Selecting one depends upon the environment in which the microphone is to work and the type of radio to be used with the microphone.

Some microphones are designed to

work in wet environments, and others are designed to work in high-noise environments. Some modern microphones have dual-tone, multiple-frequency (DTMF, or Touch-Tone) keypads mounted on the housing, and some have controls that allow the operator to change the radio's frequency or to select other functions.

Most microphone problems are caused by mechanical stress. The wires in the microphone cable may open or short as the wires are pulled and otherwise stressed during use. These problems are likely to occur in the connector and where the microphone cable enters the microphone housing.

One solution to these problems is the modular microphone composed of a separate microphone and microphone cable. The microphone cable can be replaced quickly because it attaches to the microphone with a connector. This modular design makes testing the cable and microphone fast and effective. In addition, by changing the cable, a microphone can quickly be adapted to a control head or a radio with a different microphone input connector.

The microphone element itself is another possible cause for a malfunction. The carbon microphone may malfunction because of moisture or vibration. This malfunction usually can be fixed quickly by replacing the carbon button inside the microphone. Sometimes, tapping the microphone against a solid surface is enough to make a carbon microphone begin to work again.

With a dynamic microphone, an open coil is one common cause for malfunctions. The coil can be checked with a simple continuity test. If it is open, it can be replaced with a new coil or microphone element.

The microphone switch is a frequent source for microphone malfunctions. A sticky switch usually can be fixed by applying some cleaning fluid. A worn switch may have to be replaced.

Continuity checks may be used to check whether the microphone cable or the connector is the source of a malfunction.

Because the microphone often is easy to remove, it may be one of the first things to check when troubleshooting a complaint that the radio operator cannot be heard by the dispatcher. Substitute a known working microphone for the one on the radio. Similarly, the microphone at a dispatch location may be checked by substitution.

The best performance is obtained from a microphone when the operator knows how to use it correctly. Many microphones work best when held a few inches from the mouth. Others, especially noise-canceling microphones, should be kept close to the mouth when in use.



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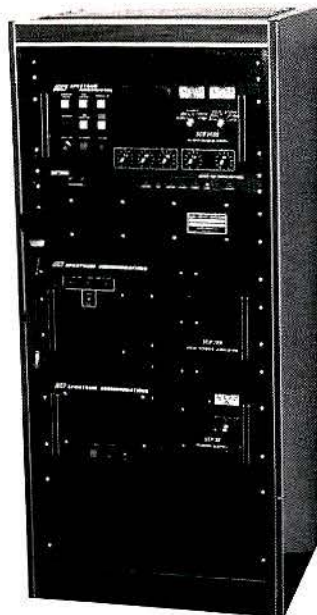
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# Rechargeable alkaline batteries for portable two-way radios

*New recharging technology makes alkaline batteries even more attractive as an alternative to nickel-cadmium batteries than before. A higher power density-to-weight ratio and less toxicity are among the advantages.*



Photo 1. The test voltage was monitored by a digital voltmeter, and the current by a precision Fluke Model 8000 milliammeter.

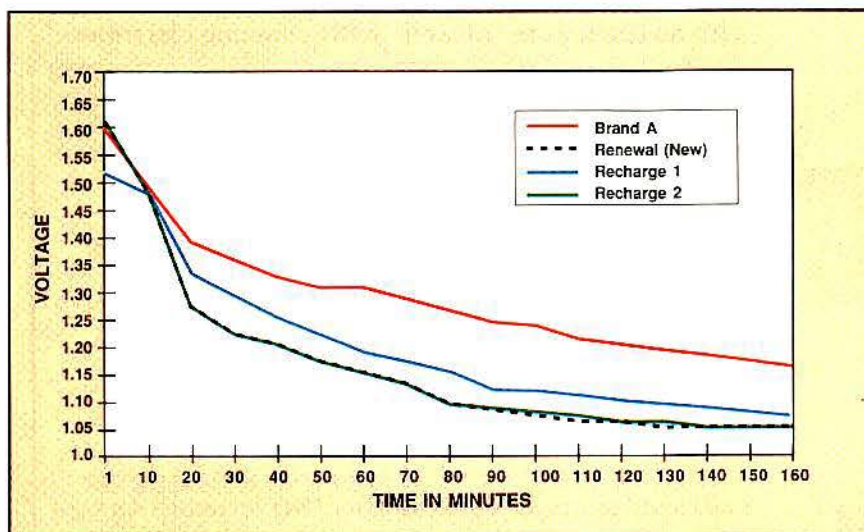


Figure 1. Voltage vs. time for the "Brand A" composite of values obtained from several tests of two brands of conventional alkaline batteries and the rechargeable battery tested fresh from the package, recharged overnight in the manufacturer's charger, and then repeatedly tested after several discharge and charge cycles.

By Donald E. Koehler

Portable radio users who need a high power density-to-weight ratio often prefer alkaline batteries to nickel-cadmium (NiCd) batteries.

Examples include people who have to carry all of their equipment with them in packs, on their belts or in their hands. Some search-and-rescue operations, law enforcement actions and firefighting assignments may require extended use of portable radios where extra batteries would add to the burden of necessary equipment.

Although alkaline batteries deliver more power for a given weight than NiCd batteries, some people have avoided using them in portable radios because the batteries could not be recharged. It costs much more to replace non-rechargeable alkaline batteries than to recharge NiCd batteries. Moreover, many environmentally conscious people do not want to add to the millions of disposable batteries that end up in landfills every year.

## Rechargeable alkaline battery

Based on technology it purchased from a Canadian company, Rayovac has perfected a rechargeable alkaline battery.

It offers a power density comparable to conventional alkaline batteries at a reasonable cost and with none of the quirks of NiCd batteries. It even boasts several "green" features, such as almost no mercury content and no cadmium.

With a shelf life that the manufacturer puts at five years and the ability to be recharged, this battery is sure to be a hit with environmentalists.

The kind of battery-powered equipment

Koehler is the owner of Communication Specialties, Anchorage, AK.



people have and the way they use it differs, so to evaluate the new battery's performance, I designed a simple test to compare different types of batteries. Although the test may not directly relate to any specific piece of equipment, it allows a one-to-one performance test under controlled conditions. The test results also have the advantage of being easy to replicate.

#### Current sink

The battery under test, in this case a single AA cell, is hooked to a constant-current "sink." In this test, the current sink is a common flashlight bulb. It changes resistance and draws an almost steady current under varying voltage conditions. As the battery drains, the voltage drops, but the current draw in the test circuit remains essentially the same. The voltage and current in the circuit were monitored, and the results were recorded.

The test voltage was monitored by a digital voltmeter, and the current by a precision Fluke Model 8000 milliammeter. (See Photo 1 on page 77.) The resulting data plots are displayed in Figure 1 on page 77 and Figure 2 above. Please note the overall curves and not the absolute values.

"Brand A" is a composite of values ob-

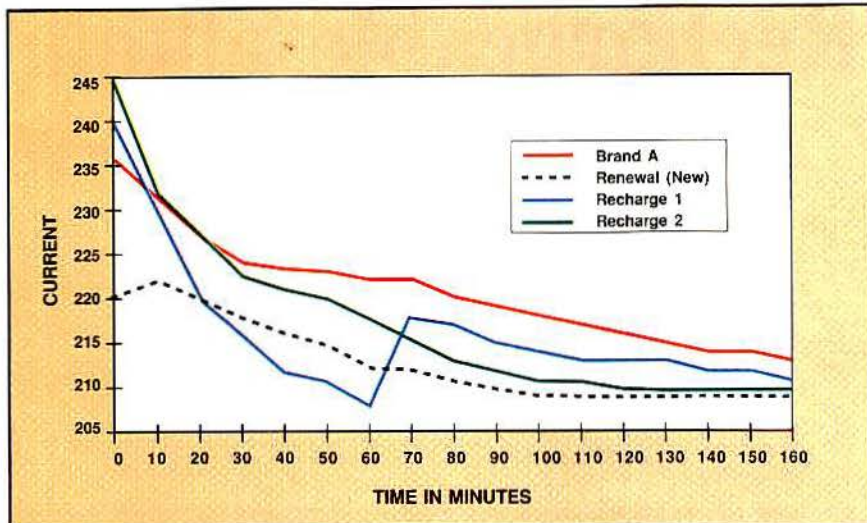


Figure 2. Current vs. time for the "Brand A" composite and the rechargeable battery. After several cycles, the rechargeable battery's test results remained essentially the same. The only anomaly in the series happened during the test following the first recharge, when a current spike showed about an hour into the test.

tained from several tests of two brands of conventional alkaline batteries. The rechargeable battery was tested fresh from the package, recharged overnight in the manufacturer's charger, and then repeat-

edly tested after several discharge and charge cycles.

After several cycles, the rechargeable battery's test results remained essentially the same. The only anomaly in the series

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happened during the test following the first recharge, when a current spike showed about an hour into the test. It never occurred again. The data sets are otherwise unremarkable.

#### Battery performance

Table 1 below shows some common electronics equipment and the amount of current they use. You may infer battery performance in that equipment by comparing current draw to test results. In other words, the rechargeable battery produces

significant amounts of current (210mA) even after more than 2.5 hours of steady draw.

A member of Rayovac's technical staff suggested 1.0V is a good benchmark for removing the battery from service to begin recharging. Even so, the battery can be completely discharged without damage. I drained one cell until no voltage was indicated, and then recharged it overnight. After charging, the battery voltage reached 1.61V. Such a complete discharge is not recommended, but at least if it hap-

pens occasionally, it will not ruin the battery. Discharging a NiCd cell that way may ruin it.

#### Observations

Rechargeable alkaline batteries exhibit the same performance curve as conventional alkaline cells, although their absolute values are somewhat lower. Their performance clearly exceeds NiCd cells in the same working environment.

The failings of NiCd cells have been amply documented, such as the rapid drop-off of current vs. voltage and the dreaded memory effect that seems to depress cell voltage or charging capacity. Neither failing affects the rechargeable alkaline cell.

The shelf life is defined as the time required for a new, unused battery's charge to drop to 85% of a full charge. The manufacturer claims the shelf life exceeds five years, and I have every reason to believe it.

Even after repeated charges, the battery provided power for my portable equipment. How many times can it be recharged? As with NiCd batteries, it depends on how you use the cell. Twenty-five to 100 charges would be a reasonable expectation.

To recharge the batteries, you must use the manufacturer's recharger. One model

Table 1- Some common electronic equipment types and the amount of current they use.

EQUIPMENT	VOLTAGE	CURRENT DRAW	CONDITIONS
SG-789 shortwave receiver	4.5Vdc	60mA 33mA	w/o headphones w/ headphones
S2002 shortwave receiver	6.0Vdc	60mA 53mA	w/o headphones w/ headphones
IC-2AT VHF FM transceiver	9.0Vdc	45mA 265mA	Rx squelch off Tx high power
P-38 wideband scanner	7.5Vdc	75mA 42mA 38mA	squelch off Rx normal Scanning

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is a compact, four-cell version for AAA and AA cells. (See Photo 2 to the right.) A second eight-cell "family" station handles cell sizes from AAA to D.

Both chargers use 117Vac and charge the cells with a proprietary pulse-current circuit. No provision has been made yet for a 12Vdc charging adapter. A 200W inverter to drive the chargers would suffice for remote operational needs until the manufacturer produces a 12Vdc vehicle charger.

**CAUTION:** If your equipment is configured to charge its batteries when connected to external ac or dc power, remove the rechargeable alkaline batteries before you connect the equipment to external power. If the batteries need recharging, charge them in the battery manufacturer's charger. This precaution will save both the cells and your equipment.

#### Bottom line

The battery pays for itself after the second recharge. Or, at prices in Anchorage, AK, with merely 25 charges or more, I save more than \$20 per cell. As a bonus, using rechargeable alkalines means fewer batteries are discarded as waste, and when a rechargeable alkaline battery does reach

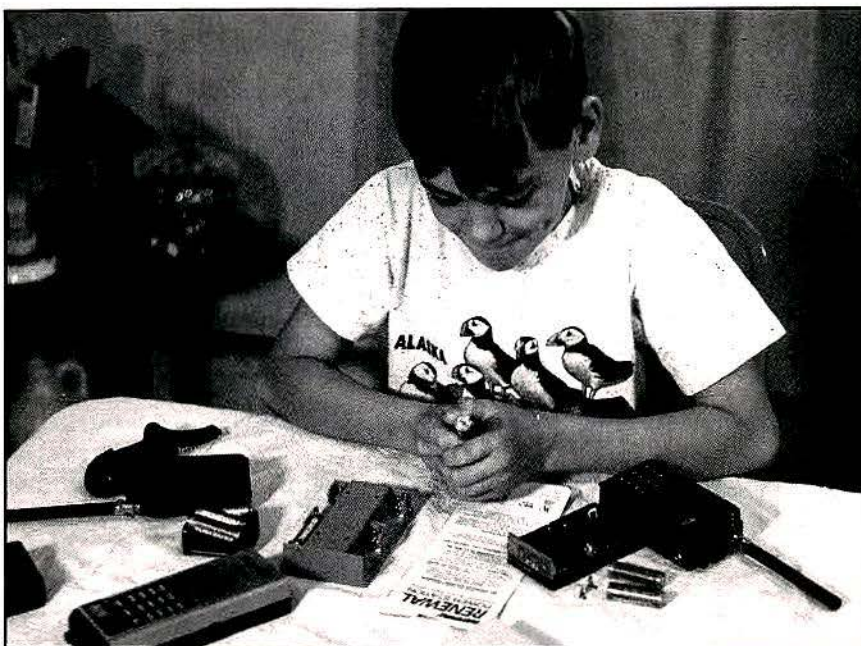


Photo 2. To recharge the batteries, you *must* use the manufacturer's recharger. Here, the author's son, Robert, loads batteries into a compact, four-cell recharger for AAA and AA cells.

the landfill, it contains much less hazardous material than a NiCd battery.

Users of portable equipment and people

in remote locations will find the rechargeable alkaline battery an economical way to power their equipment.



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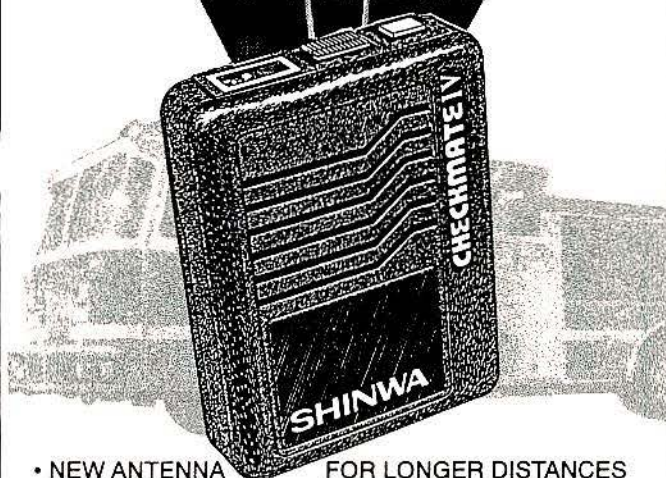
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## Technically speaking

(continued from page 8)

fairly simple procedure approximates the ambient noise level. First, the "bench" sensitivity of the receiver used at the site should be measured. For example, suppose the sensitivity of a receiver is checked and found to be  $0.25\mu\text{V}$  for 12dB SINAD.

To determine the "site" sensitivity, use the setup in Figure 1 on page 8. The setup uses two type UHF tees and a type UHF barrel coupling. One of the UHF tees is an off-the-shelf connector. However, the other tee, an "iso-tee," is a homemade device used to sample a signal for feeding the input of sensitive instruments. The iso-tee is made from a regular tee connector by removing the center pin of the connector, cutting it short off and reinserting it into the tee connector. The center pin can be reinserted by sawing a small slot in the end to accept the head of a screwdriver.

The loss or "isolation" caused by the iso-tee in Figure 1 may be 30dB, 40dB or 50dB. It is not important exactly how much isolation is provided as long as the isolation prevents the signal generator from loading the transmission line connected to the receiver input. The  $50\Omega$  load at the regular tee connector properly terminates the signal generator. Padding can be used between the signal generator and the regular tee to further improve impedance matching.

If the  $50\Omega$  load is not used at the regular tee connector, it is possible that a quarter-wavelength of line between the signal generator and the tee connector could reflect a short circuit at the output of the signal generator. The  $50\Omega$  load prevents the line length from adversely affecting the signal generator output.

With the setup shown in Figure 1, the first step is to connect the load termination resistor to the iso-tee and to increase the signal generator level to produce 12dB SINAD at the receiver output. As usual, the generator is set to a deviation of  $\pm 3\text{kHz}$  by a 1kHz modulating tone. The signal generator output level is noted at this point.

Disconnect the load termination from the iso-tee and connect the antenna. The noise from the antenna should degrade the 12dB SINAD reading. Increase the signal generator output level until the SINAD meter again indicates 12dB SINAD. Note the signal generator output level. The difference between this generator output level and the previously noted level is the amount of degradation the site noise is causing to the system sensitivity.

For example, if the difference in signal generator levels is 3dB, the site noise is causing a 3dB degradation to the system sensitivity. If the bench sensitivity was  $0.25\mu\text{V}$ , then the system sensitivity is

3dB worse. To determine the effective sensitivity in microvolts, refer to the graph in Figure 5 on page 85. As shown on the graph,  $0.25\mu\text{V}$  is equivalent to -119dBm. Add the 3dB degradation to -119dBm to get -116dBm. This level is equivalent to a little more than  $0.35\mu\text{V}$  as shown on the graph. Technically speaking, the amount of transmission line loss should be included to get the total system sensitivity. Thus, if you get 3dB degrada-

tion from the measurement and the transmission line loss is 2dB, then the total system degradation is  $3\text{dB} + 2\text{dB} = 5\text{dB}$ .

### Attenuation versus site noise

When the effective site sensitivity test is performed, at least 3dB difference is normally seen when changing between the antenna and load termination. Otherwise, line loss is probably reducing system sensitivity. When high site noise is present,

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$$dBm = 10 \log \left( \frac{E^2 \times 10^{-9}}{50} \right) \quad [1]$$

$$dBW = 10 \log \left( \frac{E^2 \times 10^{-12}}{50} \right) \quad [2]$$

$$dBW = dBm - 30 \quad [3]$$

$$dBm = dBW + 30 \quad [4]$$

$$E = \text{antilog} \left( \frac{dBm + 107}{20} \right) \quad [5]$$

$$E = \text{antilog} \left( \frac{dBW + 137}{20} \right) \quad [6]$$

where:

dBm = signal level in decibels referenced to 1 milliwatt in 50Ω,

dBW = signal level in decibels referenced to 1 watt in 50Ω,

E = voltage level across 50Ω in microvolts.

the line attenuation does not adversely affect "system" sensitivity unless the line attenuation reduces the site noise (from the antenna) to a level within 3dB or 4dB of the receiver input noise. This is an important point to remember.

### Case in point

To measure the effects of attenuation in the presence of high site noise, the following procedure was followed. The noise in this particular case was very high and was caused by "hardware" noise from a power line near the receiving antenna. At times, the noise was very severe and at other times, hardly noticeable. It seemed worse on dry, low-humidity, days. The receiver was operating on the VHF highband at 159MHz.

The bench sensitivity of the receiver was measured and found to be 0.25μV or -119dBm. Formula 1 in the box to the left can be used to convert microvolts to dBm, and Formula 5 can be used to convert dBm to microvolts. Next, using the setup in Figure 2 on page 8, the signal generator output was adjusted to produce 12dB SINAD at the receiver output. The attenuator shown between the iso-tee and the receiver input is a step attenuator and was initially set to zero attenuation (except for

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the small insertion loss). The signal generator level required to produce 12dB SINAD was -70dBm.

Next, as shown in Figure 3 on page 8, the 50Ω termination was removed from the iso-tee, and the antenna was connected. Again, the signal generator level was adjusted to produce 12dB SINAD at the receiver output. The generator output level at this point was -52dBm. Thus, the noise from the antenna was degrading the system sensitivity by a whopping 18dB! Now the object was to learn how much attenuation could be inserted (by the step attenuator) before the 12dB SINAD reading was degraded.

First, 10dB attenuation was switched in with no noticeable effect on the SINAD reading. Next, 3dB more attenuation was switched in without noticeably affecting the SINAD reading. The attenuation was now 13dB. An additional 2dB of attenuation was inserted with only the slightest degradation to the 12dB SINAD reading. The attenuation was now 15dB. Next, inserting 1dB more attenuation (for a total of 16dB attenuation) caused a significant reduction (more than 2dB) to the SINAD reading.

Thus, as long as the attenuation was 3dB or 4dB less than the measured degradation caused by the noise from the antenna, there was little or no effect on the system sensitivity. What this means is that, as far as system sensitivity goes, the line loss or other losses placed on the line could be as much as 14dB without degrading the system sensitivity. This is in addition to the line loss already present.

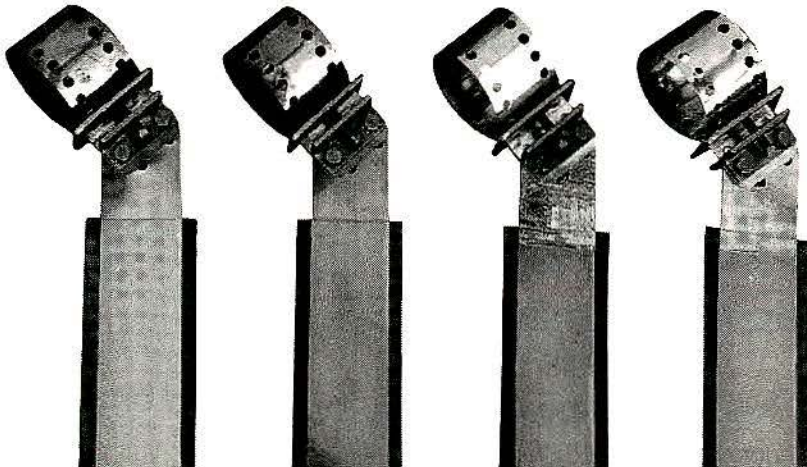
If the line loss or other attenuation between the iso-tee and the antenna were very high (say 25dB), the test just conducted would have shown no degradation to the system sensitivity with the antenna connected vs. having the load termination connected. This would be the result because the large line loss would have reduced the noise level from the antenna to a very small level at the receiver input.

With the severe noise from the power line present, the system sensitivity was reduced from 0.25μV to just under 2μV. This level is shown in the graph in Figure 4 on page 84. Here, 0.25μV is converted to -119dBm as shown. Next, 18dB is added to the -119dBm figure to get -101dBm. Then the -101dBm signal level is converted to about 2μV on the graph as shown.

#### Absence of power line noise

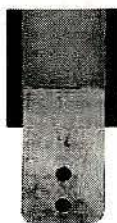
When the power line noise went away, additional measurements were made to determine the system sensitivity in its absence. The same setup used previously, Figures 2 and 3, were used again.

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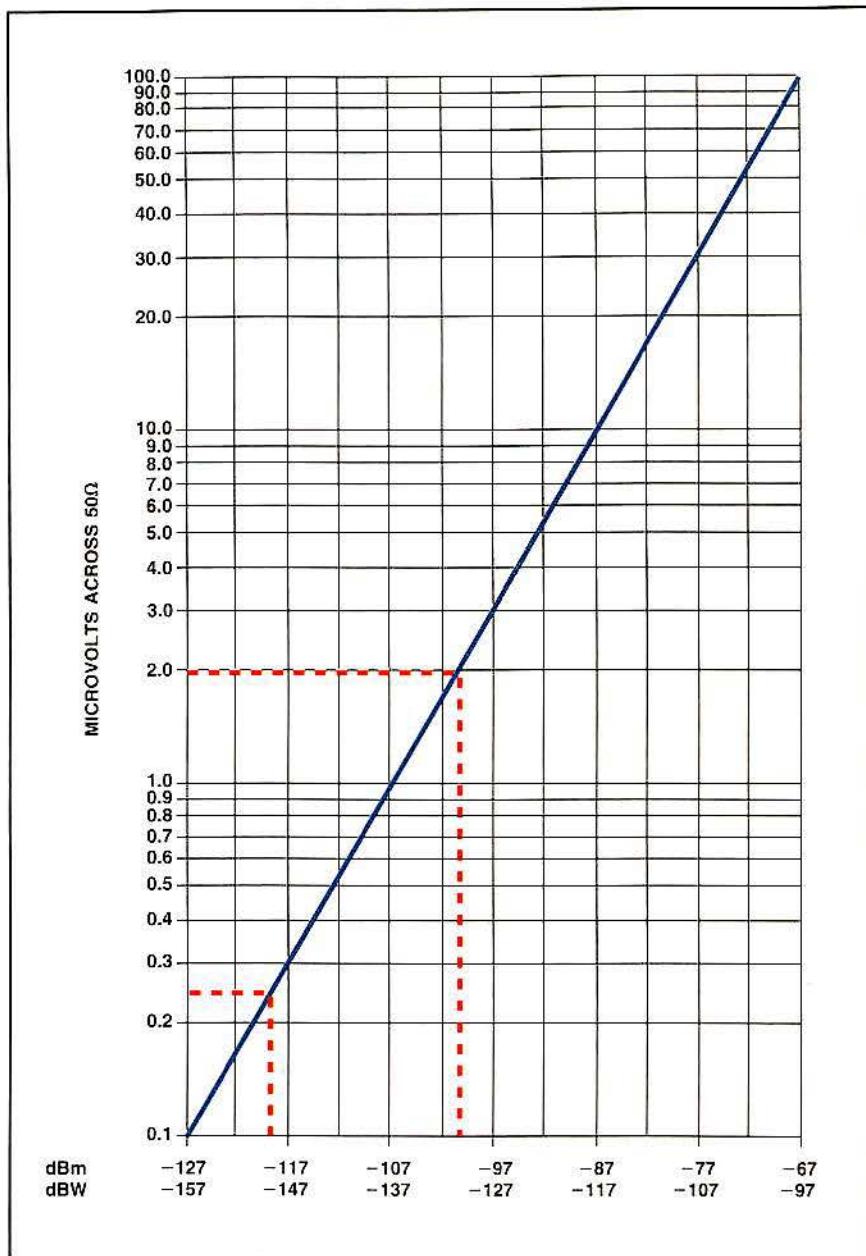


Figure 4. Voltage levels across 50Ω from 0.1μV to 100μV can be converted to dBm or dBW by using this graph.

This time, the difference between having the antenna connected and having the 50Ω load termination connected was 3dB. Thus, the site noise in the absence of power line noise was very low. It was expected to be, because the site is in a rural area, and no other transmitters were operating at the same site at the time. Switching in as little as 1dB attenuation on the attenuator caused significant degradation to the SINAD reading at the receiver output.

### Conclusion

It is important to keep in mind that the limiting factor on system sensitivity is site

noise level. Where site noise levels are very low, transmission line losses or insertion losses of cavities and other passive devices can degrade the system sensitivity. However, where site noise is fairly high, the small insertion losses of cavities and other passive devices will cause little harm to the system sensitivity.

What about the transmitter? It would follow that if the system sensitivity is reduced by 3dB or 4dB from site noise, what harm would be done by reducing the transmitter output level by the same amount? Probably very little. It does no good to transmit further than we can receive,



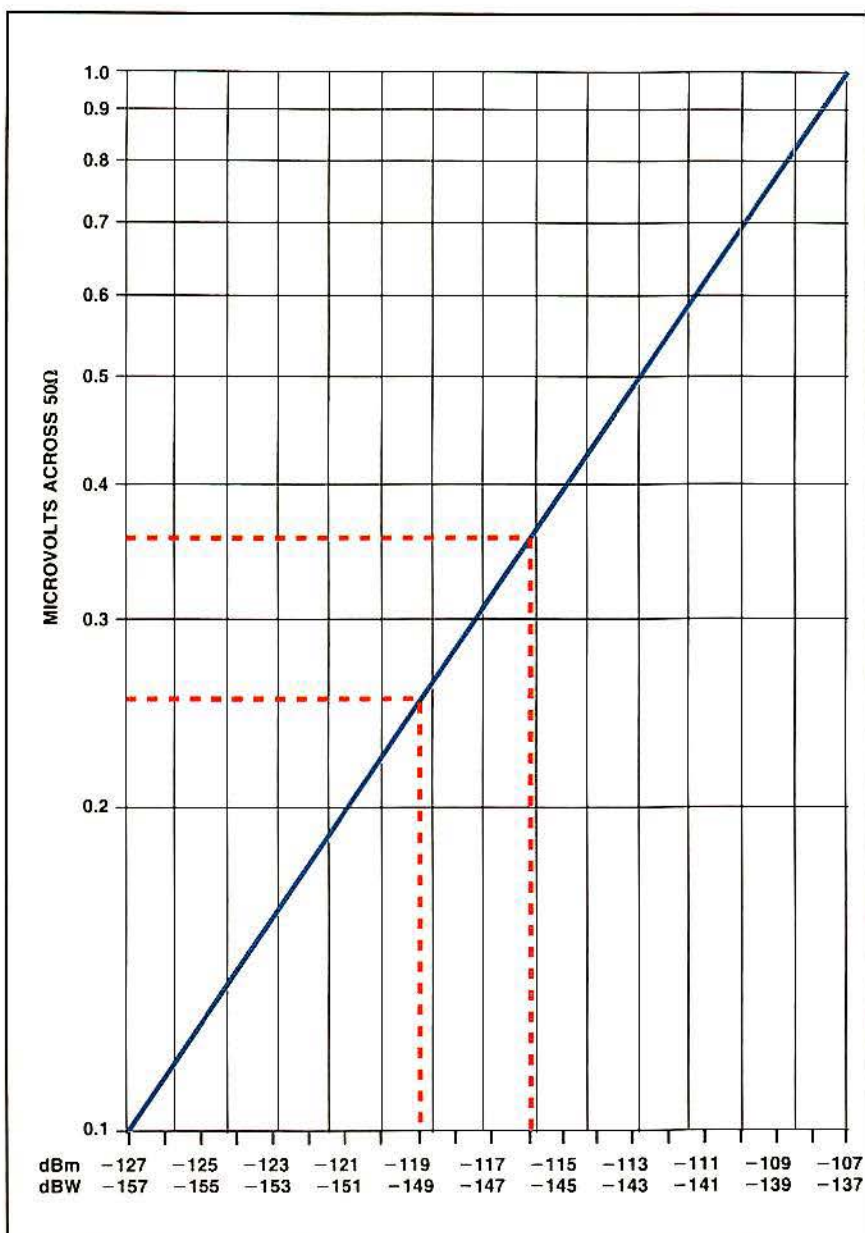


Figure 5. Voltage levels across 50Ω from 0.1 μV to 1 μV can be converted to dBm or dBW using this graph.

because this is a two-way radio system and not a broadcasting system.

Remember, too, that the site noise is not always constant. It can vary at your receiver depending upon which transmitter(s) might be "up" at the time of the measurement.

In running this type of test, be aware of possible desense caused by nearby transmitters. The isolation coupler described will behave differently at higher frequencies. It may be necessary to use a directional coupler at higher frequencies to reduce impedance discontinuities.

It is good to be cautious about keeping line loss and other losses to a minimum, but be aware of the fact that sometimes the negative effect of losses is not quite what one might expect it to be. Make it a point to know what your site system sensitivity is. Better yet, record the measurement for future reference. By so doing, you will be aware of increasing noise levels at the transmitter site and how the noise is impacting your communication system.

Although not everyone agreed on all points, several opinions were solicited. Thanks to George Weimer, Trott Communications Group; Dr. Gregory Stone, Booz, Allen & Hamilton; and Jim Hendershot, Radio Design Group for their comments. If you would like to shed some light on the subject, you are invited to write the author at 204 Tanglewylde Drive, Spartanburg, SC 29301-2949.

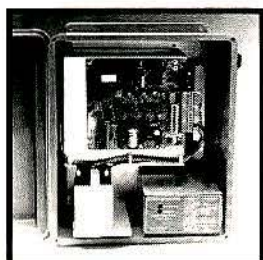
That's all for now. 'Til next time ... *stay tuned!*

#### Reference

1. Anciaux, Louis N., "GaAs FET Preamps Boost System Performance" Parts I and II, March/April 1983 and May 1983 *Mobile Radio Technology*.
2. Mann, Ernest N., "How Tower Top Amps Improve Reception," April 1989 *Mobile Radio Technology*.

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## The Voice of Reason

By Robert H. Schwaninger Jr.

The telecommunications industry is changing rapidly, and with those changes are coming chaos, confusion, realignment of interests and general growing pains. Smaller operators are being shoved off

some of the radio spectrum, and larger operators are encamping on channels that they never used before. New technologies are changing information delivery systems, and new strategic alliances are being formed daily.

Yesterday's monopoly finds itself beset with new and innovative competition. Local operators compete with regional operators that compete with national operators that are buying technology from firms that

do business around the globe. The industry is experiencing the effects of horizontal integration, vertical integration and new niche marketing in every area. And with each new transition comes the chafe of change.

From the consumer's viewpoint, some changes cannot happen fast enough, and others would be better if they never happened. Some services cannot deliver the promised efficiencies that the research and development engineers thought possible. Other services cost so much that they are unattainable. Then there are those services that deliver every imaginable service as a bundle of goods when the consumer just wanted a little, plain dispatch service.

The FCC is culling its inventory of spectrum, both the older allocations and allocations that the federal government is surrendering. The agency is trying to find new ways to auction each of those culled blocks to reduce our burgeoning federal budget deficit. Congress is on another deregulation kick, which always includes removing entry barriers to the industry while eliminating protection for existing operators.

The effect of these forces creates conflict. Cable companies battle the wireline operators. Personal communications services (PCS) will cause problems for cellular telephone carriers. Enhanced specialized mobile radio (ESMR) changes the market for SMR. The Personal Communications Industry Association (PCIA) competes with the Cellular Telecommunications Industry Association (CTIA). The FCC takes on the GOP. The list goes on and on.

In each battle that rages, the tone and temper of the argument that ensues quickly reaches a fever pitch. Each side claims that the American Public will suffer if its point of view is not adopted. Vitriol is used time and again, and the purple prose gets distributed widely. Being one of the authors of these many documents, I, too, have used my pen as a weapon in fighting for my clients' interests.

But, standing back from the fray of my most recent challenge, it appears to me that much of the saber-rattling and table-thumping is more about the aggravation of change and the pain of progress than anything else. No industry goes through substantial change without protest, parades of lobbyists, politicking and puffery. This industry is similarly not immune.

For all of the changes that are rapidly

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Schwaninger, *MRT's* regulatory consultant, is a partner in the law firm of Brown and Schwaninger, Washington, DC. He is a member of the Radio Club of America.



emerging, I have not seen one that did not create additional opportunity. Even when an operator has been challenged in the marketplace for one service, the same change has created new opportunities for

additional services. Each time a large company takes over one part of the industry or territory, it creates new avenues of opportunity in its wake.

The entrepreneurial spirit of this industry is incredible and indefatigable. It rebounds and emerges again and again. Each time there is a cry that all of the skunk works are about to close, another fifty appear and technology is pressed forward again. For every large market, a thousand niche markets exist and serve millions of customers.

Perhaps the most amusing part of this ever-evolving process is that today's bitter enemies become tomorrow's cooperative partners. Operators that have declared a pox upon another carrier's house find themselves entering into agreements to cooperate and mutually benefit through the efforts of that previously cursed carrier. In fact, I have actual evidence that Congress and the FCC sometimes agree!

The lesson to be learned is that no matter what is said or written,

it all is usually blown away by the winds of change. Intelligent businessmen realize that after each battle, the slate is cleaned and we begin again, taking up the next cause and choosing a new set of allies and enemies. Often too much is made of the rhetoric of battle and not enough time is spent on the reality of the marketplace—that change is inevitable and that the smart operator is the one that anticipates and takes advantage of change.

Finally, one piece of sage advice. Because the battles are often fought within legal forums, we lawyers (aka "hired guns") are often at the front of each fight. Never confuse the lawyer with his or her client. I am pretty sure that F. Lee Bailey does not own a white Bronco. Remember, the lawyer does not say or do anything unless the client is being served. In most cases, when the dust clears, the attorneys can be found sharing a friendly drink at their local watering hole, talking about how they will be cooperating on the next issue. In fact, if I run into any of my worthy opponents at the next trade show, I will offer to buy the first round.



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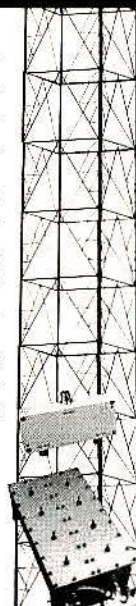
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## Simmonds consolidates Midland, SCL Systems, Roamer One into public-company Intek Diversified

Simmonds Communications Ltd. (SCL), Toronto, announced on March 9 that it has signed a letter of intent to sell its communications businesses to a public company, Intek Diversified, Los Angeles, in exchange for 15 million shares of Intek common stock. Intek is primarily involved in developing a nationwide 220MHz specialized mobile radio (SMR) network. Upon completion of the transaction, SCL will own about 73% of Intek and thus retain control of the communications businesses. Based on the March 8 closing price of \$3.50 per share of Intek stock, the transaction would be worth \$52.5 million. (At our deadline, March 29, Intek stock was selling for \$4.00 per share.)

The SCL businesses to be sold to Intek include: Midland International Corp. (Midland), Kansas City, MO; the operating assets of Midland International Ltd., Toronto; and the operating assets of an SCL division, SCL Systems, Pickering, Ontario, Canada. Among other things, the transaction gives Midland employees, customers and others an opportunity to invest in Midland as a U.S. public company. SCL

acquired Midland in 1993 for about \$10 million, but benchmark valuations for the other businesses are unavailable.

Midland is a distributor and value-added reseller of communications products for the professional land mobile radio, consumer citizens band and marine radio markets. Midland International Ltd. distributes Midland products outside the United States. SCL Systems is a systems integrator for wide-area radio communications networks. In 1994, these businesses had combined sales of \$67 million.

Previously, SCL and a Torrance, CA-based and privately held company, Roamer One, formed a joint venture, Simrom, to deploy a nationwide 220MHz specialized mobile radio (SMR) dispatch network using a combination of 2,250 channels either managed by Roamer One or owned by its principals. Roamer One placed its assets into the joint venture, and the SCL Systems division of SCL was given the responsibility for designing and constructing the Roamer One network. Then the Simrom joint venture was sold to Intek in exchange for Intek stock. Simrom was re-

named Roamer One, and it became an Intek subsidiary. After the merger, the pre-merger Intek shareholders owned 33% of Intek; pre-merger Roamer One shareholders owned 40% of Intek; and SCL owned 27% of Intek.

Intek had been an injection-molded plastics equipment manufacturer with most of its shares owned by its management. These shareholders were willing to allow the Simrom joint venture to control the company and to change its business to radio communications to increase the value of Intek stock—and it subsequently increased nearly tenfold to about \$3 per share. Nicholas Wilson, chairman of the pre-merger Roamer One, was named Intek chairman. SCL president and chief executive officer John G. Simmonds was named Intek chief executive officer. SCL chief operating officer Harry Dunstan was named Intek president. David W. Niebert, president of the pre-merger Roamer One, became president of the Intek Roamer One subsidiary. The 220MHz network gained immediate status as a public company without the delays and uncertainties

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associated with an initial public offering.

Intek entered into an agreement that was announced Feb. 27 to sell machinery, tooling, equipment, inventory and patents related to electro-static discharge and material-handling products for \$2.7 million to InterMetro Industries, Wilkes-Barre, PA. These assets are owned by an Intek subsidiary, Olympic Plastics. Olympic's remaining assets are expected to be sold by mid-1995. Proceeds from the sale will be used to fund SMR network development.

According to information released at Midland's ProCom dealer meeting in Nassau, Bahamas, Feb. 27-March 1, Midland dealers can expect increased systems sales support. They also have been extended an opportunity to share in recurring revenues if they contract as a Roamer One reseller or dealer for airtime sales.

Increased radio communications systems sales support comes through a reorganization of SCL businesses already in effect at the time of the meeting. SCL placed the administration of North American sales for SCL Systems with the Midland Land Mobile Radio (LMR) division led by Midland sales vice president Scott Henderson.

"Trunking *appears* to be king," said SCL Systems U.S.A. sales manager Joe Gallelli, "but 800MHz is not for everyone. Conventional business persists, and while the delivery of ESMR services is *late*, PCS will be even *later*." Gallelli said that complex system features are available on conventional systems that are better-suited than 800MHz trunking for the wide-area, low-density radio communications typical of light suburban, rural and municipal governments and school districts. Together with SCL Systems, Midland plans to help its dealers to bid such systems.

John Simmonds told the dealers that the reason SCL bought Midland 18 months ago was to build systems. "Where we make money today is on systems business," he said. "Eighty percent of the contribution to the bottom line comes from systems business and high-end products." He said dealers already are successful in selling medium-size systems, and SCL wants to help them to sell large systems.

In further support of system sales, Midland plans to fill in its line of branded products to more fully cover the various components of systems, to provide marketing materials and to provide dealer training.

Mark Wood, Roamer One's national sales manager, told the Midland dealers that they can participate in mobile equipment leasing and airtime sales on the network, either as a "reseller" or as a "dealer." SCL Systems and certain Midland dealers

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## News

already are helping to build the network's repeater stations.

"Resellers are expected to have an aggressive marketing presence and technical skills," Wood said. Resellers who handle the billing for their network customers, lease or sell Roamer One-branded mobile dispatch radios and sell airtime, earn an ongoing share of recurring revenue.

For dealers who do not want to bill subscribers, Roamer One offers a dealership

status. Roamer One sends the bills and shares recurring revenue for a period following subscriber activation.

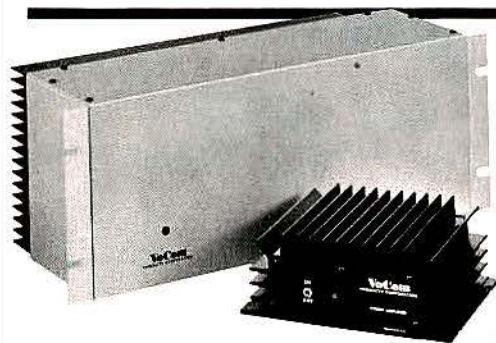
Wood said that the Roamer One radios will be feature-rich and are expected to be capable of carrying data at 9,600bps.

Among new products announced at the meeting, Midland introduced a VHF highband multimode mobile radio in versions with 32 or 160 channels and 50W or 110W output. It can be programmed by

channel for either a 12.5kHz or a 25kHz bandwidth. The selectable bandwidth makes it suitable for future migration to narrowband channels that may result from FCC rule changes and for compatibility with 25kHz units in the meantime.

Also at the meeting, Midland announced that it has discontinued its 70-1336 low-end mobile radio, arranging instead for it to be manufactured and sold by Lett Electronics, Topeka, KS, for at least three years. Under the contract with Lett, the unit will be sold to Midland dealers with no change in pricing.

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### E.F. Johnson acquires narrowband technology rights

E.F. Johnson, Burnsville, MN, has completed a series of agreements with Securicor Communications, Surrey, United Kingdom. E.F. Johnson has acquired a non-exclusive license to the intellectual property rights for Securicor's narrowband radio communications technology. Securicor has purchased a significant minority interest in E.F. Johnson.

E.F. Johnson radio systems that are built on the very narrowband linear modulation technology (LM) will carry as many as five times more voice and data messages than current systems.

### SpaceCom, Motorola announce licensing agreement

SpaceCom Systems, Tulsa, OK, and Motorola's Global Paging Infrastructure Group, Fort Worth, TX, have announced a licensing agreement that will allow Motorola to manufacture and sell satellite receivers that use SpaceCom's proprietary FM Cubed technology.

FM Cubed is a digital satellite transmission technology developed by SpaceCom in 1991 that uses time-division multiplexing and encryption.

The FM Cubed licensing agreement will allow Motorola to manufacture an FM Cubed satellite receiver that is a fully integrated, internal component of Motorola's Nucleus paging station.

### Racotek to provide services over Ericsson's EDACS networks

Racotek, Minneapolis, has signed an agreement with Ericsson, Lynchburg, VA, to provide metropolitan, statewide and regional wireless data and voice communication services over Ericsson's Enhanced Digital Access Communications System (EDACS) trunked radio networks. Racotek will integrate its KeyWare Wireless Distributed Computing environment to the EDACS network by the second quarter of 1995.

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### ElectroCom provides radio system controllers to city of Fort Worth

The city of Fort Worth, TX, has extended the life of its mobile data communications system (MDCS) while expanding its capabilities with a new radio system controller from ElectroCom Communication Systems, Santa Fe Springs, CA.

The existing MDCS operates over two 45MHz radio channels. The city added three conventional 800MHz radio channels, with each channel operating from transceivers installed at three sites, to expand the coverage area for the MDCS and to take advantage of the 800MHz frequency spectrum.

The city replaced the existing radio controller, which supported only the 450MHz system, with ElectroCom's new Radio Data Controller, RDC-101. The unit can accommodate all sites and all transceivers in the expanded network. ElectroCom also provided the city with its Received Signal Strength Indicators (RSSI) for each of the transceivers.

### Motorola to supply equipment for wireless messaging network

Motorola's Advanced Messaging Systems Division (AMSD), Fort Worth, TX, and Destineer, a subsidiary of Mtel, Jackson, MS, have agreed that Motorola will provide Destineer with messaging equipment for the first nationwide ReFlex two-way wireless messaging network.

ReFlex, a member of Motorola's Flex family of high-speed transport protocols, is optimized for data messaging.

The Destineer network will incorporate ReFlex along with a new line of Motorola-manufactured infrastructure equipment and Motorola's Tango, the first two-way pager.

### Glenayre, MobileComm form partnership to build test system

Glenayre Technologies, Charlotte, NC, and MobileComm, Jackson, MS, have formed a technology partnership to build a test system of two-way wireless messaging services.

MobileComm, the wireless messaging subsidiary of BellSouth, will begin beta testing of new services in mid-1995 with Glenayre equipment. The company recently purchased a license to provide nationwide two-way messaging over a 50kHz outward and 12.5kHz return channel through the FCC's auction of narrowband Personal Communications Services (PCS) spectrum. The new two-way services will be tested on MobileComm's PCS channel in Dallas.

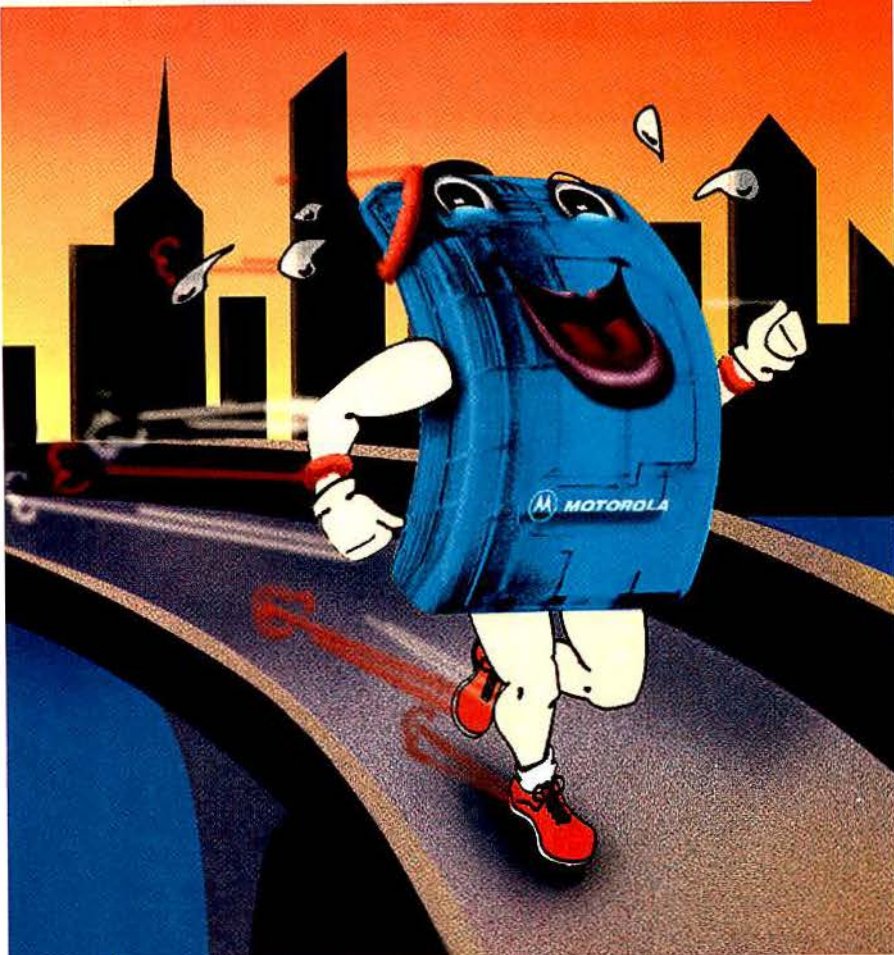
### Glenayre Technologies, Western Multiplex to merge

Glenayre Technologies, Charlotte, NC, and Western Multiplex, Belmont, CA, have signed a definitive agreement to merge the two companies. The merger will be effected by a tax-free exchange, with the allotment of 500,000 (pre-split) shares of Glenayre common stock to the shareholders and optionholders of Western Multiplex. The transaction will be accounted for as a purchase and is expected

to close in the first quarter.

Following the transaction, Western Multiplex shareholders and optionholders will own about 2.6% of Glenayre on a fully diluted basis. Western Multiplex will operate as the Western Multiplex division of Glenayre and will continue to market its products under its brand name and trademarks. Western Multiplex management will be retained after the merger.

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### Geotek, Hughes Network Systems form strategic alliance to develop products for Geotek's FHMA networks

Geotek Communications, Montvale, NJ, and Hughes Network Systems (HNS), a unit of Hughes Electronics, are forming a strategic partnership to develop a series of subscriber terminals and equipment based on Geotek's proprietary FHMA technology. The first products to be available will include a portable subscriber unit and a vehicle-mounted mobile handset.

Geotek is placing an initial order for 10,000 handsets for vehicle-mounted mobile units and an order for 100,000 portable subscriber units. The vehicle-mounted mobile units, which will be based on HNS' digital mobile design, will be available in the third quarter of 1995, and the portable subscriber units will be available in 1996. The value of both or-

ders is about \$65 million.

Under the terms of the agreement, HNS and Geotek will share equally the cost of developing the portable subscriber unit. As part of the transaction, HNS will grant Geotek partial vendor financing. A portion of the financing will be based on Geotek meeting certain performance criteria. The vendor financing will be used to purchase terminals and other equipment from HNS.

### Teknow moves to new headquarters

TekNow has consolidated its operations from three locations to one with the move to its new corporate headquarters at 4909 East McDowell Road, Phoenix, AZ. The new facility was designed and renovated for TekNow's expansion requirements to manufacture and distribute the PhenX wireless messaging system. The telephone number is 602-266-7800.

### Magellan signs merger agreement with Orbital Sciences

Magellan Systems, San Dimas, CA, signed a merger agreement with Orbital Sciences, Dulles, VA, under which Magellan will become an independent subsidiary within Orbital's Communications and Information Systems Group. In a transaction valued at about \$60 million, Orbital will exchange about three million shares of its common stock for all of Magellan's outstanding stock. Magellan will continue to do business under the Magellan name, will keep its employees and will stay in San Dimas.

Magellan will design, manufacture and market hand-held data communications transceivers under the Magellan name for Orbital Science's new ORBCOMM system, a wireless, two-way messaging network. When completed in 1996, ORBCOMM will consist of 26 low-earth-orbit satellites providing virtually real-time worldwide data communications services to customers around the globe.

### AirTouch Paging to distribute Seiko MessageWatch

AirTouch Paging, Dallas, has become the newest distributor of the MessageWatch from Seiko Communications of America, Beaverton, OR. The company will start with retail sales and service of the MessageWatch in Southern California and the Pacific Northwest and expects to add more markets as Seiko Communications deploys its network nationwide.

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## Readers' choice

Of all the new products and services in the September 1994 issue, the one reprinted here generated the most reader requests for additional information. If you missed it the first time, here is your opportunity to acquire more information on it. Just circle the corresponding Fast Fact Card number on the card found in the back of this issue and mail the card to us.

### Hand-held, wide-range receiver memorizes 1,000 channel locations

The Trident TR-1200 wide-range, hand-held receiver from Ace Communications receives voice broadcast frequencies from 500kHz to 1.3GHz. Its demodulation modes are: AM for broadcast and worldband, and for civil and military aviation; narrowband FM for police, fire and emergency transmissions; and wideband FM for radio and TV audio broadcasts. Desired frequencies are entered on the front keypad, and entries are displayed on a backlit LCD. The unit searches for active channels and allows the user to store as many as 1,000 locations in permanent memory. Ten search ranges can be set and entered into memory by the user. The 5 7/8"H x 2"W x 1 1/2"D unit comes with a built-in speaker, an earphone, a dc adapter plug, an ac battery charger, a belt clip and a flexible antenna.

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### Monitor provides remote control for paging, cellular transmitters



BayTech's M3 DAC (Data Acquisition Controller) monitors and controls remote transmitters. Designed for cost-effective and comprehensive remote operations, the unit can manage multiple paging or cellular transmitter operations. Typical installations allow users to dial into remote transmitters, check equipment status and then hard-set the attached equipment. The controller can regulate analog and digital inputs, monitor voltages, and open and close external relays. The M3-DAC chassis is the base used to build the system, which includes an internal modem host port, serial I/O ports and a control relay module.

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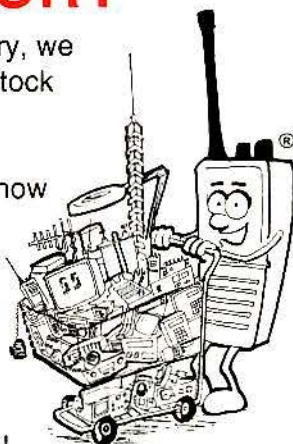
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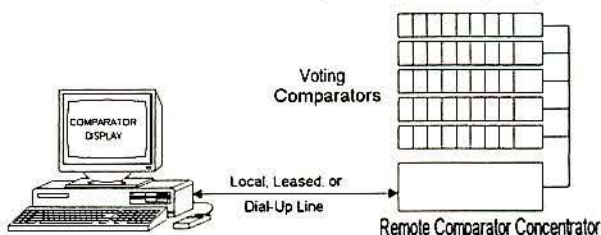
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Circle (87) on Fast Fact Card



## New products

Adapter converts Bendix/King portables into mobile radios



Modular Communications has introduced three models of Vehicular Mobile Adapter Chargers (VMACs) designed to adapt Bendix/King VHF and UHF portable radios to mobile use. The base model features 8W of audio power, external speaker, microphone, installation kit and a quarterwave broadband antenna. It also provides rapid or trickle charging of the portable's battery. A PTT current-boosting feature allows transmission even when the portable has a discharged battery. The intermediate model adds a 50W broadband RF power amplifier. The third model combines the 50W RF power amplifier with features for emergency vehicles such as siren generator, public address and light bar controls.

Circle (402) on Fast Fact Card



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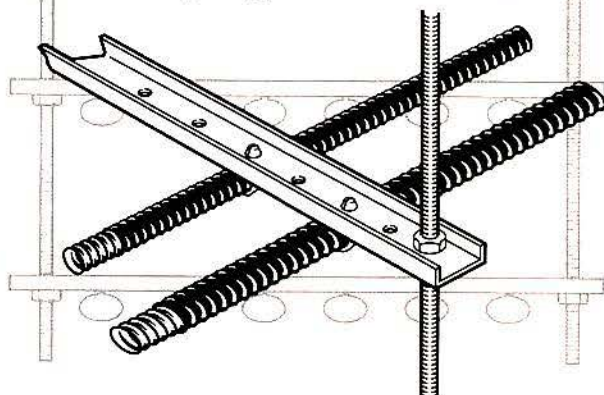


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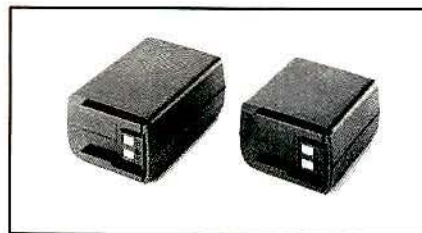


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Circle (89) on Fast Fact Card



Battery replacements provide choice of available capacities



Battery replacements for Yaesu, Standard and Maxon radios have been added to the line offered by **W&W Associates**. Battery capacities of 7.2V at 1,400mAh and 7.2V at 1,800mAh are available for the Yaesu VX500, FNB29 series. A 9.6V battery at 900mAh is available as a replacement for the Standard HX580, CNB-584A series. Battery capacities of 10.8V at 600mAh and 10.8V at 1,500mAh are available for the Maxon SP 2000 series.

Circle (403) on Fast Fact Card

Personal communications unit combines information, paging



The Pan American Subscriber Paging division of **Motorola** has introduced the Info information receiver/pager, which combines alphanumeric paging with 24-hour information services. The operating protocol, licensed to Motorola by NewsPager Corporation of America, allows reception of as many as 20 information services, including UPI Headline News, UPI Sports, Dow Jones updates, and weather. The pager can be programmed to alert the user when a specific item from any database fits a user-specific interest, such as unusual stock activity or a sporting event score. The unit will trigger an audible or silent page alert for as many as 20 points of personal interest. The unit has a 120,000-character memory and can view four 20-character lines of information at a time.

Circle (404) on Fast Fact Card

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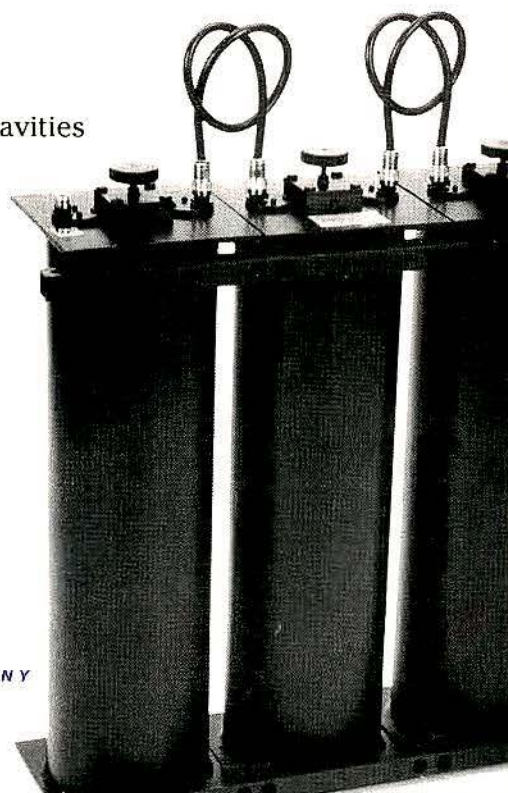
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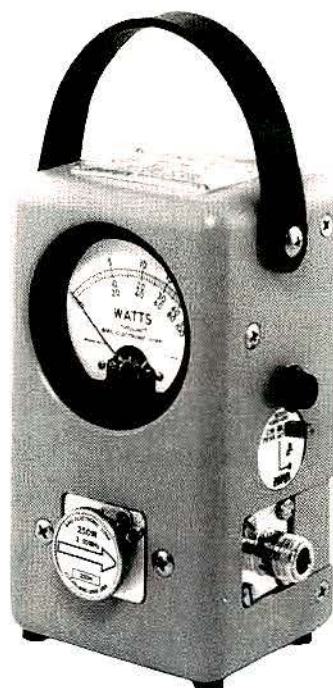
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Circle (91) on Fast Fact Card



## New products

### Sectionalized monopole reduces costs incurred in transportation, erection

The Qwikpole monopole for antenna mounting from **Tower Structures** is manufactured and assembled in sections to avoid extra transportation costs or site difficulties sometimes associated with one-piece monopoles. All sections are transportable on a standard 40-foot flatbed truck. The sectionalizing of the pole also allows the use of lighter con-

struction cranes for erection. Transmission lines and coaxial cables are mounted internally to decrease wind-load, weathering and vandalism. The design of the pole allows for direct embedment for fast installation and includes a rotatable mount for adjustments in antenna positioning.

Circle (405) on Fast Fact Card

### Reflectometer offers extended storage, direct function keying



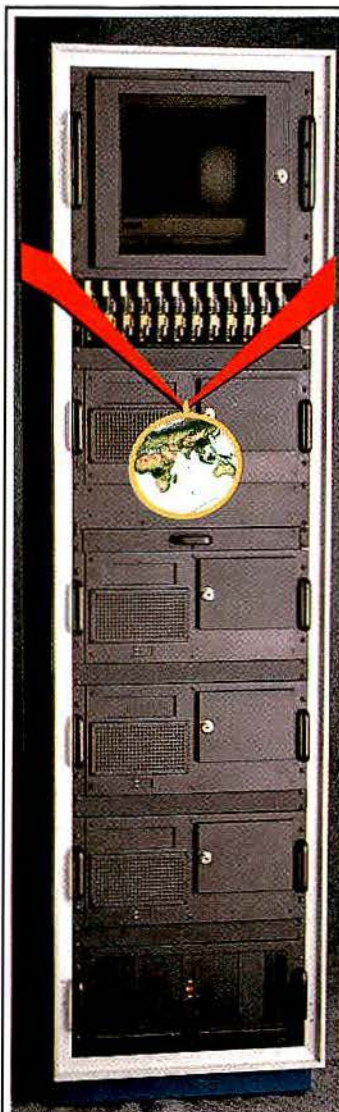
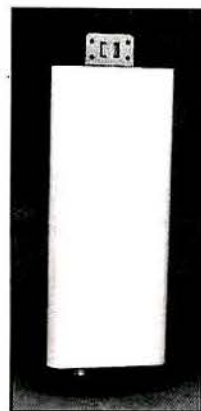
Designed for coaxial cables, the 1205C Time Domain Reflectometer from **Riser-Bond Instruments** will also test twisted pairs. An exclusive Super-Store feature provides extensive waveform storage. All on-screen and off-screen cable sampling data can be viewed at a later date at all gain levels. Other features include auto-search, automatic fault severity calculation and independent cursors. All of the unit's functions can be accessed from a dedicated key without the need for menu selection.

Circle (406) on Fast Fact Card

### Homogenous aluminum panel design virtually eliminates intermodulation

Designed to virtually eliminate intermodulation, **CELLite** directional panel antennas from **Celwave** are manufactured in one piece of aluminum alloy, including dipoles and microstripline feeding network, then welded into a reflector box. The all-aluminum assembly and lack of material discontinuity in the welding significantly reduces the possibility of intermodulation. Available for systems operating from 824MHz to 1.990MHz and beamwidths from 33° to 120°, the large bandwidth of antennas is 20% for a VSWR of less than 1.5:1. For smaller bandwidths, VSWRs of less than 1.2:1 in the transmit band and 1.3:1 in the rest of the band can be achieved.

Circle (407) on Fast Fact Card



## PRISM II Paging Systems by TGA are WORLD CLASS

TGA PRISM II paging systems are designed to meet the standards used by international telephone administrations such as:

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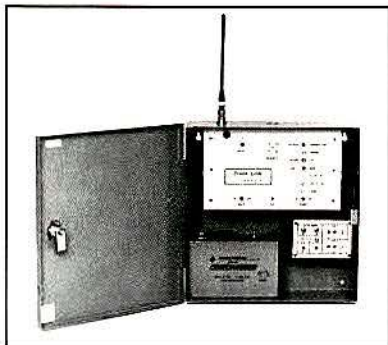
**TGA**  
Systems, Inc.

**PRISM**

Circle (92) on Fast Fact Card



**Alarm system transmits voice messages over two-way radio**



CES Technologies' Crime-Link Radio Alert System can be wired to an existing alarm control panel, or it can stand alone. When tripped, the unit instantly transmits voice alarm messages over a two-way radio system. The system can store two field-programmable voice messages that can be individually tripped. Package features include battery backup, DTMF remote control, accessory power jack, low battery indicator, power supply, whip antenna and wall-mount enclosure. Remote control features include arm/disarm, system status, voice message check, remote surveillance microphone activation and relay activation. Radio transceiver packs are available in all frequency ranges including 800/900MHz trunked systems.

Circle (408) on Fast Fact Card

**Disguised antenna fits requirements for surveillance, anonymous use**

STI-CO Industries' 800 series (XXX-S-800) disguised, cowl-mount, two-way antennas cover cellular and trunking frequency ranges from 806MHz to 866MHz. The disguised antennas are exact AM/FM antenna replacements for select Ford, Chrysler and GM body styles. Optional AM/FM broadcast couplers are available. Designed for law enforcement surveillance applications, the antennas also can be used for marked public safety vehicles and by users who want anonymity for personal mobile cellular phone use. The 31" masts are solid stainless steel.

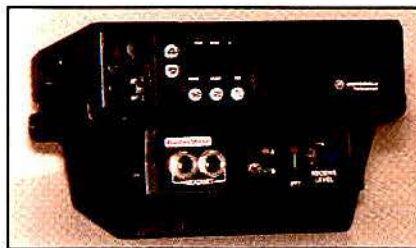
Circle (409) on Fast Fact Card



**Switch allows use of multiple communication devices with one headset**

The Switchmate II from RadioMate permits use of multiple communications by a driver without removing the headset. The unit allows users to switch between vehicle telephone and radio equipment hands-free by use of a footswitch. The Switchmate II installs on a pedestal below the radio.

Circle (410) on Fast Fact Card



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Circle (86) on Fast Fact Card



## New products

### Computer-aided radio system allows monitoring for taxi dispatch

Pacific Circuit Design has developed an affordable computer-aided radio system for taxi dispatch. Using a 486DX 66MHz PC, the dispatcher can monitor taxi system activity and selectively dispatch taxis. A taxi logs onto the system by sending a two-digit number with a DTMF radio microphone. A complete set

of 15 commands allows a taxi to communicate with the dispatcher without the need for voice contact. Individual drivers and vehicles are identified at the start of a shift. An emergency panic button is included for driver problems. Taxis are listed by zone with or without stand reference.

Circle (411) on Fast Fact Card

### TDMA digital cellular base antenna provides high front-to-back ratios

Decibel Products division, Allen Telecom Group, has engineered the Digital Dominator, a base station antenna, specifically for digital cellular systems. Operating with 13dBd gain at 820MHz to 900MHz, the antenna is designed for TDMA systems. It provides broad bandwidth (80MHz), sharp patterns and high front-to-back ratios for high-density sites. The high-gain antenna provides a precise 14° vertical and 70° horizontal signal pattern with a 34dB front-to-back ratio. Mounting options include monopole structures or AMPS-style platforms. An option is also available for mechanical downtilt.

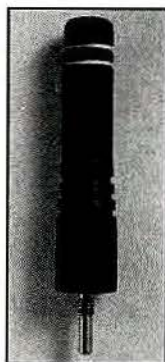
Circle (412) on Fast Fact Card



### Technophone replacement antenna doesn't interfere with portability

Centurion International's replacement antenna for the Technophone 405/415 portable phone allows the user to improve reception and performance. Available in the quarter-wave version, the replacement's compact size allows the phone to fit easily in a pocket. Two versions are available: the 3 1/2" CXC antenna and the CXS stubby antenna.

Circle (413) on Fast Fact Card



### System monitors alarms, sends page when one is activated

Zetron's model 7230 Central Alarm Paging System is designed for large security applications such as power plants, hospitals and industrial complexes. The system is capable of monitoring as many as 450 alarm points simultaneously. When it senses an alarm condition, the system sends a user-programmable alphanumeric message to the appropriate display pagers.

Circle (414) on Fast Fact Card



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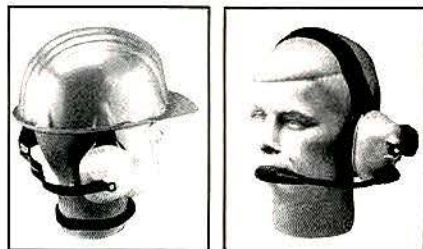
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Circle (87) on Fast Fact Card



## Self-contained mic vox modules eliminate need for headset interface



Two communications headsets from **David Clark Company** feature self-contained vox modules, eliminating the need for any other equipment to interface between the headset and the radio. The model H7245 (above left) comes with a noise-canceling electret throat microphone held in place with a soft, adjustable Velcro fabric strap. The model H7240 has a noise-canceling electret microphone mounted on a flexible boom for easy mic adjustment. Both headsets operate in noise levels to 125dB and can be worn with or without safety head gear. The vox modules are powered by a rechargeable NiCd battery to prevent drain on the radio's power supply.

Circle (415) on Fast Fact Card

## Mobile data hardware peripherals expand information capabilities



**Dinet** has created several hardware peripheral options for its Data Mate series of mobile data terminals. The peripherals are available for all standard or customized models. New devices include a built-in GPS receiver for AVL; a 40-column plain paper serial printer; an 80-column thermal serial printer; a remotely mounted 4 x 40 (160 character) LCD; a magnetic credit card swipe reader; and a barcode reader in card swipe or pen wand models. Also available is an expanded serial card option that makes three additional serial ports available for peripheral equipment.

Circle (416) on Fast Fact Card

## Laminates protect sensitive devices from local EMI/RFI interference

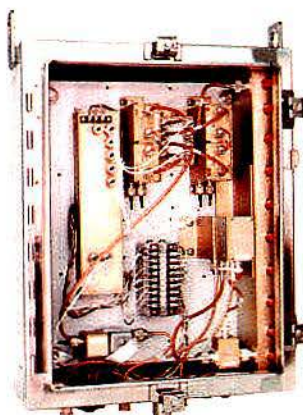
**Lamart's** Electroshield laminates protect electronic devices that are sensitive to EMI/RFI interference. Available with or without a pressure-sensitive adhesive, the copper and aluminum foils are laminated to a high-strength polyester film that resists punctures and abrasion.

Circle (417) on Fast Fact Card



## 422-Series Auto-Backup™ Tower-Mounted Preamplifier Systems

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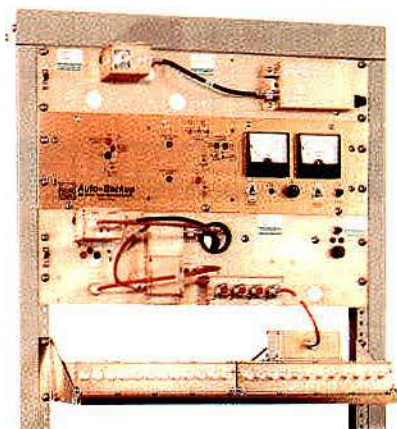
Model 422-86A-07-18-117  
Auto-Backup Tower-Mounted  
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- **Auto-Backup** system (US and other patents pending) monitors primary preamplifier and switches to backup preamplifier in case of primary failure.
- Secondary preamplifier is normally off-line and isolated from events that would destroy both amplifiers in competitive parallel-connected, "redundant" systems.
- High-selectivity, six- to ten-section combine preselectors for trunking, AMPS and GSM bands in 5, 10, 12.5, 15, 18 and 25 MHz bandwidths.
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Circle (88) on Fast Fact Card

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## New products

### Small numeric pager is available in both POCSAG, Flex formats

The MessageMaker Exec numeric pager from NEC America is the first release of a new MessageMaker series. Measuring only 2.5" x 1.81" x 0.79" and weighing just 2.19 ounces, the pager is the smallest ever offered by NEC. Available in both POCSAG and Flex formats,

the pager features two-button operation, 16-message storage, selectable alerts, baud programmability by carriers and a reminder alert. Other features include selective message deletion, clock and time stamp.

Circle (418) on Fast Fact Card

### Fire-retardant, plenum-rated cable has several sizes for in-building use

Andrew has expanded its line of plenum-rated Heliac coaxial cables with the addition of 1/4-inch and 1/2-inch sizes. These additions expand the company's selection to include sizes ranging from 1/4-inch to 1 3/8-inch. The cables are designed for applications where fire codes mandate plenum-rated fire retardant cables. Applications include cellular extension, low-power trunking, wireless PBX and in-building communications systems.

Circle (419) on Fast Fact Card



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Circle (89) on Fast Fact Card

### Redesign for 220MHz amplifiers reduces rack space requirements

Uniden America has designed a 125W linear amplifier package for 220MHz that requires only 14 inches of rack space. The five new modular amplifiers plug into a vertical package. A custom combo D cable combines multiple coaxial and dc control lines into one connector for quick installation. The package includes Uniden's Cartesian feedback circuit.

Circle (420) on Fast Fact Card

### Mobile mount design incorporates composite materials for strength

PanaVise Products' Slimline 2000 mobile communications mounts are made of fiber-reinforced composite material that decreases unit cost and increases durability and gripping strength. The mounting kit includes mounting plate, shaft, foot and universal joints for 210° of pivot and 360° of swivel. The mount also comes with an NEC/AMPS-compatible mounting plate with set-screw or knob adjustment. Rises of 6" or 9" are available.

Circle (421) on Fast Fact Card





## Vehicle tracking unit supports fleet management AVL system



The Geo-Trac vehicle tracking unit (VTU) from Auto-Trac has a 10-channel GPS receiver. Geo-Trac is one of three components of a fleet AVL system that allows tracking of fleet vehicles on computerized maps. Six programmable RS-232 ports support peripheral devices such as mobile data terminals, automated stop announcements, signing systems, smart card readers, dead-reckoning navigational aids and a route download source. The seventh port is a J1708 that meets transit industry standards. Geo-Trac can transmit information to the dispatcher via radio modem in one of four modes: TDMA, fast polling, on-request or by-exception.

Circle (422) on Fast Fact Card

## Lightning protectors' sampler ports allow 'on-air' testing for VSWR



PolyPhaser's IS-CS50HN and IS-PS50HN high-power, multichannel lightning protectors are designed with a sampler port and are used for combined transmit/receive applications at 800MHz-980MHz. The sampler port's BNC connector allows the port to be used for "on-air" relative spectrum analysis, time domain reflectometry testing for VSWR, power monitoring, RF sweeps, local and remote lightning strike counting and protector testing. The protectors have center pin dc blocking and as much as 60dB more attenuation of lightning frequencies than quarterwave devices. This ensures that no center pin surge current flows to protected equipment.

Circle (423) on Fast Fact Card

## Durable scanning portable radios feature 'per-channel' programming

Maxon America has introduced a SP-2000 series scanning hand portable with enhanced scanning software including priority channel scan and look-back channel capabilities. "Per-channel" programming of CTCSS and DCS tone signaling is provided for customization. The radios meet MIL-STD 810 D&E specifications for ruggedness and harsh environment. The

top-mounted control deck features a hi/lo TX power switch, a tricolor LED to identify radio status and a locking 6-pin accessory connector. Options include 600mAh or 1,200mAh slide-on batteries, DTMF keypad, speaker/microphone and a mini-vox headset and control unit for hands-free operation.

Circle (424) on Fast Fact Card

## 61st APCO Conference & Exposition August 13 - 17, 1995 COBO Conference/Exhibition Center Detroit, Michigan

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- Fire Departments
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- Many, many others

### The 61st APCO Conference & Exposition offers the attendee:

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APCO is in accordance with ADA requirements and will provide reasonable accommodations for full conference participants upon notification. Please consult the registration form in the attendee package.

Circle (90) on Fast Fact Card



## New products

### Transceiver components nest inside high noise-attenuating earmuff

Ceotronics' TC 917 UHF wireless transceiver head-set is designed for industrial communication applications or any other environment where hearing protection



must be worn. The TC 917 is fully encapsulated in a high noise-attenuating earmuff with a 25dB ANSI noise-reduction rating. Features include 10 synthesized channels with selector, integrated vox function with PTT toggle switch and a noise-canceling electret microphone on a flex boom.

Circle (425) on Fast Fact Card

### Modules, software package provide remote monitoring alternative

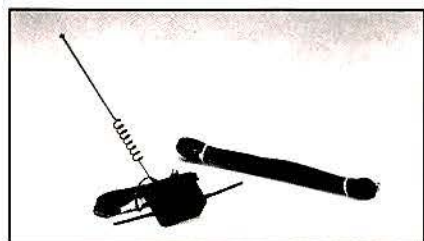
Andrew's SMART (System Monitoring and Remote Tuning) system provides remote monitoring and control of communications equipment. Applications include monitoring amplifiers and repeaters. The system consists of a sentry module in each monitored device and a PC control software package that runs under Microsoft Windows. The sentry modules communicate by landline with the controlling PC. Each module can monitor 16 digital and eight analog inputs and can



drive eight digital and four analog outputs.

Circle (426) on Fast Fact Card

### Booster antenna improves access, compensates for cable signal loss



Combining a radio frequency amplifier with a Thru Glass antenna, the Cellular Booster Antenna from ORA Electronics is designed to compensate for cables loss, improve call quality and improve cellular system access for cellular mobile phones. The antenna can be connected to vehicular cradles and hands-free kits.

Circle (427) on Fast Fact Card

### Test set simulates GPS signals for verification of installations



The GPS-101 Satellite Simulator from IFR Systems is a portable, lightweight, battery-operated test set that uses a controlled signal for verification of GPS system installations. The test set can be used on the bench to troubleshoot, maintain and verify receiver operation. RF levels and Doppler shift of GPS satellites both can be simulated. The operator can use NAV data preprogrammed into the unit or upload user-defined data via an RS-232C port. An antenna/coupler accessory is supplied with each unit.

Circle (428) on Fast Fact Card

### Field-programmable pager prints copies of alphanumeric messages



Falcon Direct's Scribe Printing Pager is a VHF field-programmable pager capable of reading and printing as many as 100 individual page messages, or when desirable, the Scribe can print all paging activity. Designed specifically for alphanumeric paging systems using standard POCSAG or RPC1 formats, the Scribe can be connected to any printer with either a serial or parallel port input. Output also can be transferred directly to a PC.

Circle (429) on Fast Fact Card

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## Catalog covers 80 new measurement products

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## Application guide includes tower lighting controls

A 16-page tower and obstruction lighting controls application guide from SSAC has been expanded to include lamp outage and beacon flasher monitoring relays. A selection guide cross-references products and applications. Included are controls for beacon flashing, synchronous flashing of beacons, dusk-to-dawn operation, lamp outage and failed flasher alarm modules and three-phase voltage monitors.

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## Buyers' guide features more than 12,000 products

An 850-page buyers' guide from Tescos features more than 12,000 products from 170 manufacturers, including full product descriptions, warranty and shipping information and complete item pricing. Tabbed sections include infrastructure, mobile and portable accessories, antennas, bench equipment and test and measurement equipment.

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## **P**eople

Changes at Transcript International, Lincoln, NE:

**Dan Allen** exits Northern Telecom, Dallas, as senior manager of network consulting to join Transcript as vice president of marketing.

**Louis Kull** departs Ericsson, Lynchburg, VA, as major accounts manager based in Omaha, NE, to become data products manager at Transcript.

**Jennifer Bohling**, international inside sales manager, advances to domestic sales state and local government manager.

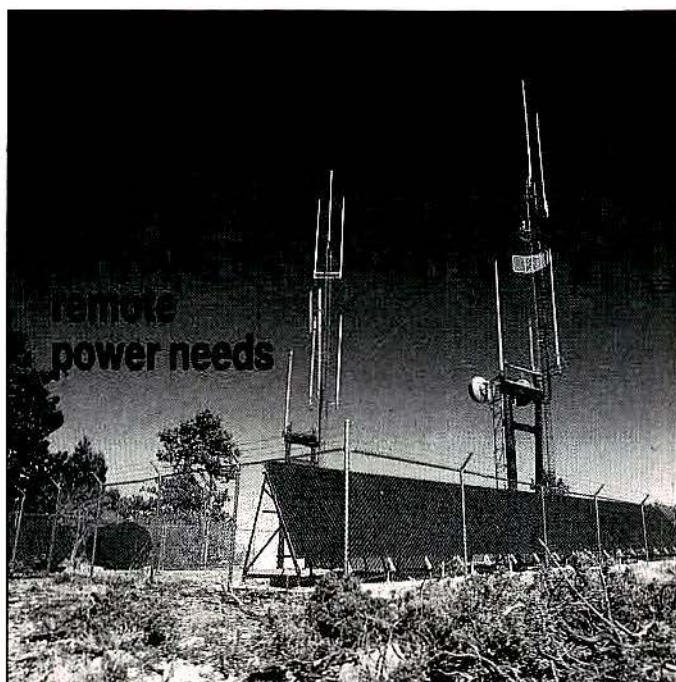
**Marvin Druskoff** departs Global/Government Communications Marketing, Fullbrook, CA, as president to join DX Radio Systems, Los Angeles, as marketing manager.

**James D. Mack**, sales manager at Sabre Communications, Sioux City, IA, advances to vice president.

**Roger Diamond** leaves Communications Associates, Joliet, IL, as major accounts representative to join the sales staff of Electronic Products, Hartland, WI.

**James R. Koehn** leaves Tektronix, Beaverton, OR, as vice president to join Marconi Instruments, Allendale, NJ, as president.

**Tom Humphries** exits Telxon, Akron, OH, as vice president of product marketing to become vice president of product development at Geotek Communications, Montvale, NJ.



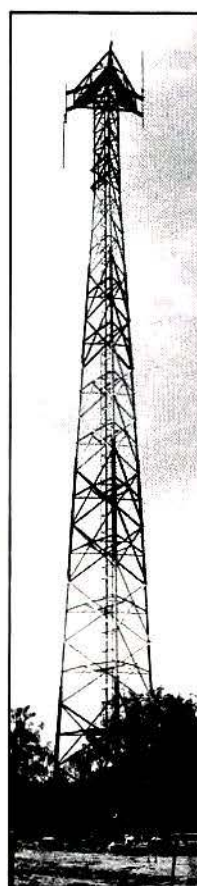
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## Classified Ad Index

Business Opportunity .....	pg 106,122
Computer Software .....	pg 125-127
Employment .....	pg 107,108
Equipment For Sale .....	pg 110-119
Equipment Wanted .....	pg 119
Lightning Prevention .....	pg 123
Manufacturers' Reps. ....	pg 107
Pager Repairs .....	pg 124
Paging .....	pg 108-110
Prof. Consulting Services ..	pg 108
Professional Services .....	pg 106
Rentals .....	pg 120
Reprints .....	pg 124
Repair Services .....	pg 123,124
Services .....	pg 119
Technicians Available .....	pg 108
Tower Services .....	pg 122
Tower Space .....	pg 120-122

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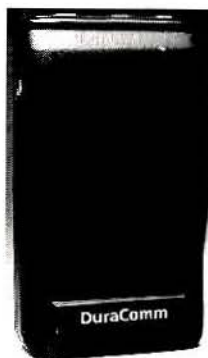
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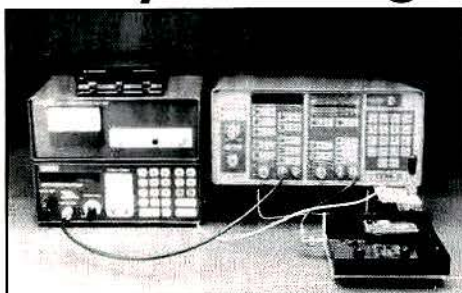
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MOT "Meratrac" 42-50MHz, 100w, 16w w/acc'y	\$500.00
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MOT "Darcom 9000" test set adaptor (FRN1818)	NEW \$100.00
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MOT/6-unit, 1-hr chgr "STX/MX" (NLN8988)	\$90.00
MOT/6-unit, 1-hr chgr "EXPO" (NLN7177)	\$150.00
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MOT/1-unit, 1-hr chgr "STX/MX" (NLN8858)	\$50.00
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MOT "HT600/MT1000" (NMN6156A)	NEW \$50.00
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MOT "STX" (NMN6177) New Style	\$50.00
As Above, Old Style (NMN6142B)	NEW \$50.00
MOT "MX" (NMN6071)	\$40.00
MOT "MX" pub sfty w/ant	\$50.00
As Above-Need Repair	3/\$50.00
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MOT "KOT 240" Mobile Data System	MAKE OFFER
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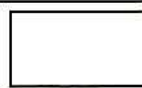
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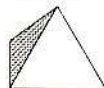
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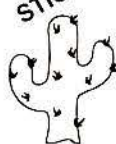


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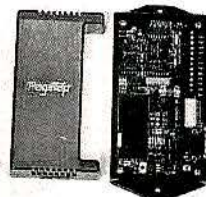
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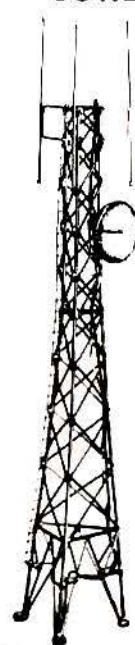
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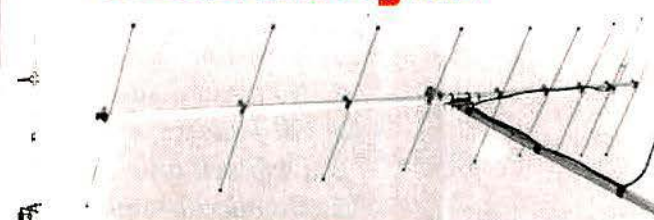
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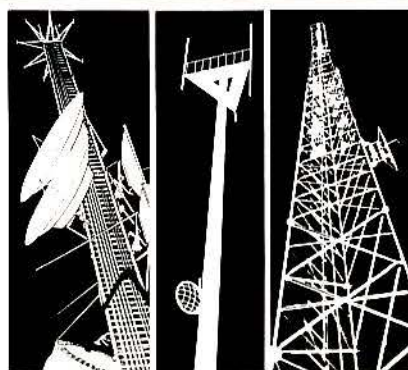
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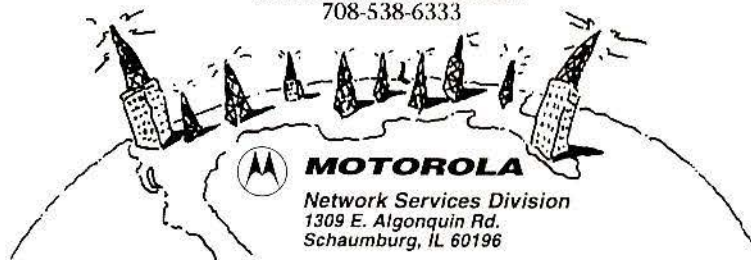
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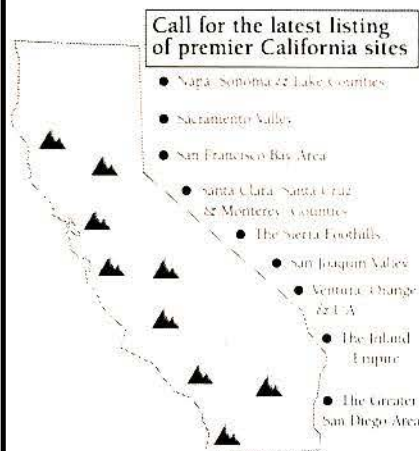
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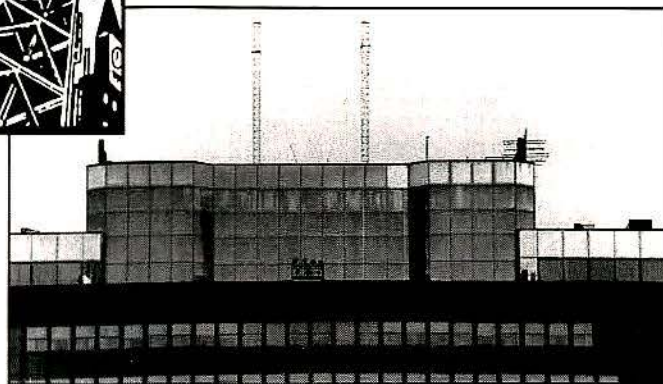
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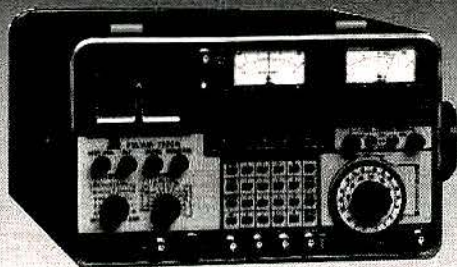
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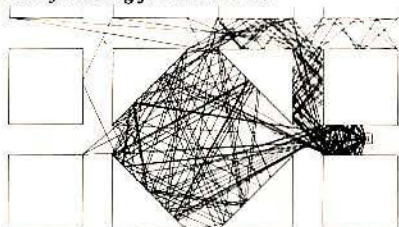
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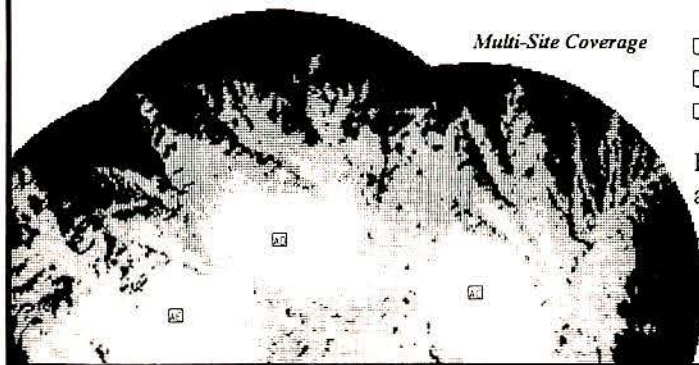
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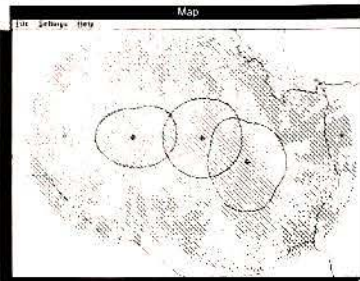
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# A d index/hot line

Company	Page Number	Fast Fact Number	Advertiser Hotline	Company	Page Number	Fast Fact Number	Advertiser Hotline
AAT Communications Corp.	121	145	908-417-3993	Microlect	48	503-363-9267	
Advanced Receiver Research	50	42	203-582-9409	Micronet, Inc.	121	146	215-491-7400
Advanced Videotech Corp.	103	92	800-233-0013	Microwave Filter Company Inc.	95	90	315-437-3953
Air Comm	111	119	602-275-4505	Midian Electronics, Inc.	37	30	602-884-7981
Alexander Batteries	46	39	800-526-ALEX	Midland International LMR	40	33	800-MID-LAND
Allen Telecom Group	IFC	1	216-349-8400	Mobile Radio Technology Reprints	124	152	312-435-2357
Andrew Corporation	26-27	21	708-349-3300	Modular Communication Systems	78	66	818-764-1333
Antennaco, Inc.	94	100	603-673-3153	Motorola Americas Parts Div.	73	63	
The Antenna Farm	117	137	800-255-6222	Motorola C&E	120	143	708-538-6333
APCO National Conference	101	90	800-949-2726	Motorola Pager Care Centers	91	84	407-364-2966
ARIS	127	159	800-874-7749	Motorola Test Equipment	5,24	6,19	800-235-9590
Astron Corporation	25	20	714-458-7277	Multiplier Industries Corp.	82	71	800-642-2424
Automation & Electronics Engr.	112	121	800-527-4596	MX-COM, Inc.	7	7	800-638-5577
Avtec Inc.	60	51	803-892-2181	NATCOM Inc.	59	50	800-844-8287
Bird Electronic Corp.	47	40	216-248-1200	New Mar	105	97	800-854-3906
B & K Precision	81	70	312-889-1448	Norton Engineering	125	154	703-938-5745
Bomar	42	35	800-526-3935	Orbacom Systems Inc.	21	16	609-829-4455
Bramco, Inc.	116	136	513-773-6255	Pana-Pacific	71	61	408-374-7900
Cadex Electronics Inc.	89	80	604-451-7900	Pekaar Communication, Inc.	116	134	201-772-0704
CELWAVE	18-19	14	800-321-4700	Photocomm, Inc.	104	95	800-223-9580
Centurion International, Inc.	9	8	800-228-4563	PIROD, Inc.	94	89	219-936-4221
Channel Element Headquarters	118	141	800-237-9654	Polaris Industries	113	123	800-752-3571
Chargeguard Corp.	98	87	800-458-3410	Polyphaser Corporation	83	72	800-325-7170
Christie Electric Corp.	28	22	310-715-1402	Positron Industries, Inc.	41	34	800-443-3313
David Clark Co., Inc.	20	15	508-751-5800	Pro-Fit International	IBC	2	612-854-6595
Combined Technologies, Inc.	93	87	513-595-5900	Pyramid Communications	114		310-430-5892
Communication Instruments	123		303-962-9998	Radio Express, Inc.	115	130	703-266-1928
Communications Associates, Inc.	116	132	800-435-9313	Radio Midwest	113	124	800-521-2468
Communications Data Services	126	156	800-441-0034	Radio Wholesale	115	129	800-53-RADIO
Communications Specialists	BC	3	800-854-0547	Ramsey Electronics	110	115	800-446-2295
Connect Systems, Inc.	15	12	800-545-1349	RCW Distributing	117	138	800-726-9015
Control Signal Corp.	38	31	303-989-8000	RELM Communications	61,87	52,76	800-648-0947
CPI Communications Inc.	32	26	214-437-5320	Ritron Inc.	67	57	800-USA-1USA
Crystronics, Inc.	109	114	305-566-6949	Rocky Mountain Comms Inc.	125,126		303-526-5454
Cushcraft/Signals Corp.	17	13	800-258-3860	Samsung Telecomms America	53	45	305-426-4100
Diablo Communications, Inc.	121	144	510-236-3700	Santa Fe Distributing	68	58	913-492-8288
D & L Communications, Inc.	84,114	73,127	800-336-6825	Selectone Corporation	23	18	800-227-0376
D & L Communications, Inc.	116,123	131,149	800-336-6825	Sentry Manufacturing Co.	110	117	800-252-6780
Doppler Systems, Inc.	88	78	602-488-9755	Serviceware Corporation	94	88	613-521-7391
Douglas Integrated Software	88	79	904-656-8673	Setcom Corp.	58	49	415-965-8020
Duracomm	108	112	913-746-8300	Sharp Communication	117	139	800-548-2484
EAGLE	52	44	602-204-2597	Shinwa			
Eagle Telecom Intl.	29	23	713-280-0488	Communications of America	80	69	800-627-4722
EDX Engineering, Inc.	125	153	503-345-0019	Shure Brothers, Inc.	45	38	800-25-SHURE
Electrocom	79	67	310-946-9493	Sinclair			
Elite Buildings	89	81	800-942-4667	Technologies, Inc.	Bellyband,56	47	905-727-0165
El Paso Communications	93	86	915-533-5119	Skaggs Telecomms Service, Inc.	69	59	801-261-4400
Ericsson GE Mobile Comms.	51	43	800-GE1-2345	Softwright	126	157	303-344-5486
E Trunk Systems, Inc.	117	140	914-245-1128	Solar Electric Specialties	92	85	800-344-2003
Everon America Inc.	86	75	800-603-3766	Solarex	97	86	301-698-4200
Factory Mutual Engineering	124	151	617-255-4842	Sonic Communications Inc.	12	9	800-688-1944
Fanon Courier	114	125	800-345-1354	Spectrum Communications Corp.	76	65	610-631-1710
Fourth Dimension	109	113	516-467-1220	Stancil Corporation	72	62	714-546-2002
Gamber Johnson	62	53	715-344-3482	Sti-Co Industries Inc.	64	55	716-662-2680
Haewa Corporation	105	98	800-783-4239	Talley Communications	87,104	77,94	800-949-7099
Doug Hall Electronics	44	36	614-261-8871	TCS	108	110	409-588-3200
Henry Radio	95,112	91,120	800-877-7979	TESSCO	43		800-472-7373
Hustler, Inc.	33	27	800-949-9490	TGA Systems, Inc.	96	92	404-441-2100
Hutton Communications	30	24	800-442-3811	Towerwatch	122	148	800-475-1780
Hy-Q International	110	118	606-283-5000	Transcrypt International, Ltd.	3	5	800-228-0226
IFR Systems, Inc.	22,65	17,56	316-522-4981	Tripp Lite	100	89	312-329-1407
JBRO Batteries, Inc.	55	46	800-323-3779	Tru-Connector Corp.	80	68	508-532-0775
JPS Communications	70	60	919-790-1011	Trylon Manufacturing Co. Ltd.	104	96	519-669-5421
KNS Electronics Inc.	44	37	408-432-8100	TX RX Systems, Inc.	99	88	716-549-4700
Larsen Electronics	39	32	800-426-1656	Uniden Corp. of America-MSG, Inc.	13	10	817-858-3300
Lazer Beepers, Inc.	124	150	800-354-3405	Vega, A Mark IV Company	1	4	818-442-0782
Leathersmith	102	91	800-233-0440	Versatel Communications	118	142	800-456-5548
Leavitt Communications	75	64	708 982-0220	Vocom/RF Corporation	90	82	800-USA-MADE
Lighthouse Engineering	116	135	800-LH-AMP-4U	Wacom Products, Inc.	90	83	817-848-4435
Marketronics Corp.	14	11	800-845-1230	WAVETEK	35	28	800-392-8100
Maxon America, Inc.	31	25	816-891-6320	West Coast Radio	115	128	310-268-2464
Maxrad, Inc.	103	93	800-323-9122	Wetec Electronics	113	122	800-249-1250
McManus Communications	110	116	501-763-6250	W&W Associates	63	54	800-221-0732
Mechem Electronics	116	133	703-891-0569	Xcel Controls Inc.	122	147	219-259-7804
Meridian Communications	49	41	818-222-5655	Zetron, Inc.	36,85	29,74	206-820-6363



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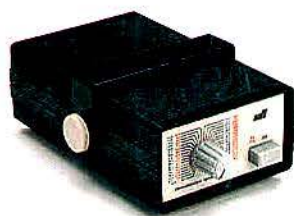
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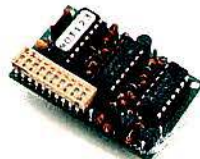
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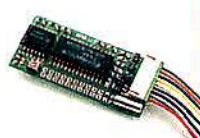
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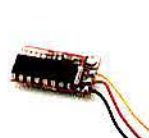
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